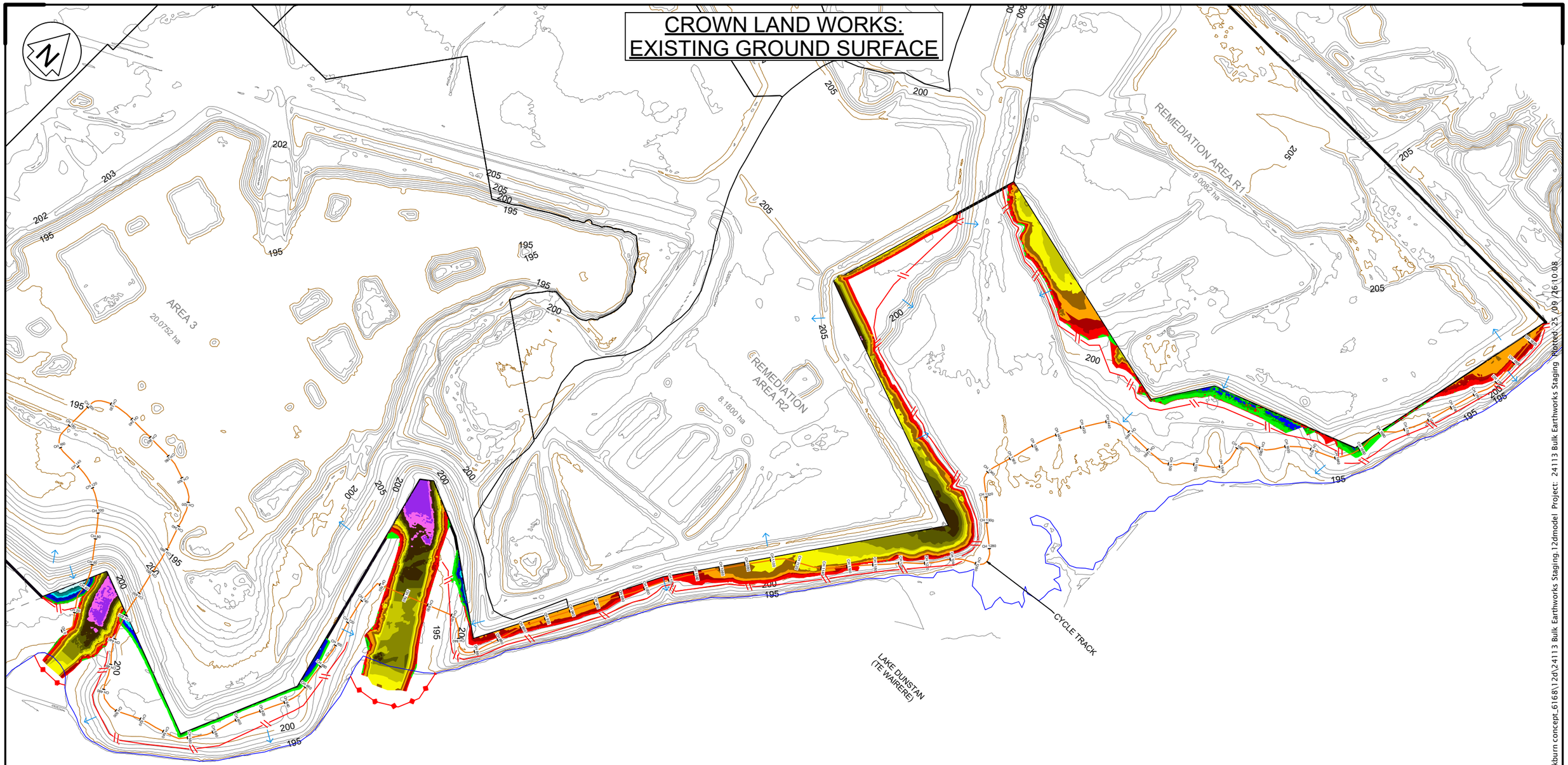
CROWN LAND WORKS: EXISTING GROUND SURFACE



0 100 200 metres

1:3000 Scale Bar

ISSUED FOR CONSENT

LEGEND

- CLEAN WATER DIVERSIONS
- EXISTING CLEAN WATER DIVERSIONS
- DIRTY WATER DIVERSIONS
- TRAFFICABLE CONTOUR BUND
- HAUL ROAD
- SILT FENCE
- SILT CURTAIN
- INFILTRATION BASIN
- SPILLWAY
- STABILISED CONSTRUCTION ENTRANCE
- GENERALISED OVERLAND FLOW DIRECTION

Folder Location: c:\12d5\data\SERVER2008R2\24113-Parkburn concept_6168\12d\24113 Bulk Earthworks Staging.12dmodel Project: 24113 Bulk Earthworks Staging Plotted: 25/09/26 10:08

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NOTES
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EROSION AND SEDIMENT CONTROL - CROWN LAND WORKS

PARKBURN DEVELOPMENT PROJECT

922 LUGGATE - CROMWELL ROAD

Rev.	Date	Revision Details	By
A	09 2026	EWK Area Interface linework added	KA

Designed: WN	Date: 04 2026	Job No.: 24113	Drawing No.: 114_07
Drawn: KA	Date: 05 2026	Scale: 1:3000 @ A3	
Checked: NKA	Date: 06 2026	Datum & Level: LP2000 & NZVD16	Rev.: A

N

Cut/Fill Depths

Lower_value		Upper_value		Colour
-10	to	-9	m	
-9	to	-8	m	
-8	to	-7	m	
-7	to	-6	m	
-6	to	-5	m	
-5	to	-4	m	
-4	to	-3	m	
-3	to	-2	m	
-2	to	-1	m	
-1	to	0	m	
0	to	1	m	
1	to	2	m	
2	to	3	m	
3	to	4	m	
4	to	5	m	
5	to	6	m	
6	to	7	m	
7	to	8	m	
8	to	9	m	
9	to	10	m	

CUT

FILL

NOTE: CUT & FILL DEPTHS ARE PRELIMINARY ONLY AND ARE SUBJECT TO DETAILED DESIGN.

FISH BARRIER

EARTHWORKS SUB-AREA 3

EARTHWORKS SUB-AREA 2

EARTHWORKS SUB-AREA 1

DIVERSION DAM

REINSTATED CREEK CHANNEL TO BE STABILISED WITH CLEAN GRAVEL AND COBBLES

CLEAN WATER DIVERSION BUND

STREAM DIVERSION (INDICATIVE ONLY - FINAL ALIGNMENT TBC VIA DETAILED DESIGN)

CREEK FLOODPLAIN AND BANKS TO BE TOPSOILED, HYDROSEEDED, AND STABILISED WITH EROSION CONTROL BLANKET/MAT

APPROX. EXISTING ACTIVE BED

AREA 9

3.5684 ha

AREA 8

5.3405 ha

REMEDIATION AREA R1

9.0082 ha

205

200

CWB

LEGEND

- CLEAN WATER DIVERSIONS
- EXISTING CLEAN WATER DIVERSIONS
- DIRTY WATER DIVERSIONS
- TRAFFICABLE CONTOUR BUND
- HAUL ROAD
- SILT FENCE
- SILT CURTAIN
- INFILTRATION BASIN
- SPILLWAY
- STABILISED CONSTRUCTION ENTRANCE
- GENERALISED OVERLAND FLOW DIRECTION

ISSUED FOR CONSENT

PARK BURN CHANNEL: EXISTING GROUND SURFACE

Folder Location: c:\12d5\data\SERVER2008R2\24113-Parkburn concepts 6168\12d\24113 Bulk Earthworks Staging\12dmodel Project: 24113 Bulk Earthworks Staging Plotted: 25 /09 /26 10.08

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NOTES
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EROSION AND SEDIMENT CONTROL - PARK BURN CHANNEL

PARKBURN DEVELOPMENT PROJECT

922 LUGGATE - CROMWELL ROAD

Rev.	Date	Revision Details	By
A	09 2026	EWK Area Interface linework added	KA

Designed: WN	Date: 04 2026	Job No.: 24113	Drawing No.: 114_08
Drawn: KA	Date: 09 2026	Scale: 1:1500 @ A3	
Checked: NKA	Date: 09 2026	Datum & Level: LP2000 & NZVD16	Rev.: A

Appendix E: ESC design details

CWBs/CWDCs – GD05 pgs 38-43

Also referred to as clean water diversions (CWDs), clean water diversion channels (CWDCs) are to be constructed as maintained as per the below GD05 typical detail, unless indicated otherwise – in some cases, CWDs may be existing and not necessarily designed to GD05 standards, but it is preferable to leave these vegetated and undisturbed rather than re-work them and expose potentially clean upslope water to contamination.

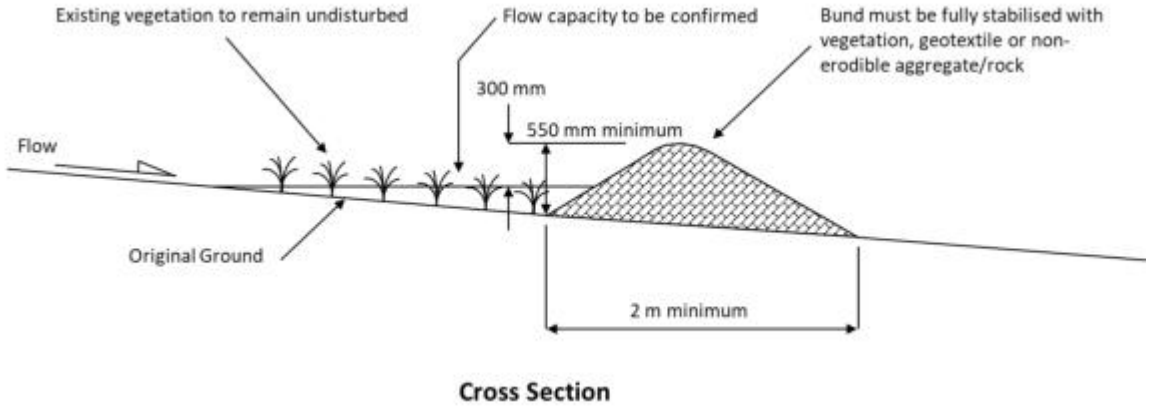


Figure 24: Clean water diversion typical detail (GD05)



Figure 25: Clean water bund with grass establishing



Figure 26: Clean water bund with established grass stabilisation

Key design criteria for CWDs are as follows:

- Ensure bunds are compacted and immediately stabilised – this may require erosion control blankets or a thick layer of hay mulch until grass can establish.
- Ensure bunds roughly follow the contour, to avoid steep gradients and runoff velocities.
- CWDs must have a stabilised outlet to prevent scour, such as riprap.

DWBs/DWDCs – GD05 pgs 43-46

Dirty water diversion channels (DWDCs; DWBs; DWDs) are to be constructed and maintained as per the below GD05 typical detail unless the attached calculations indicate otherwise. Where DWDC longitudinal grade exceeds 2%, they should be lined (preferably with HDPE) or stabilised with either a thick coating of polymer or topsoil and hydroseed, to prevent scour. Unlined DWDCs should be monitored for scour, and may require retrospective lining where scour risks undermining the integrity or shape of the channel as shown below.

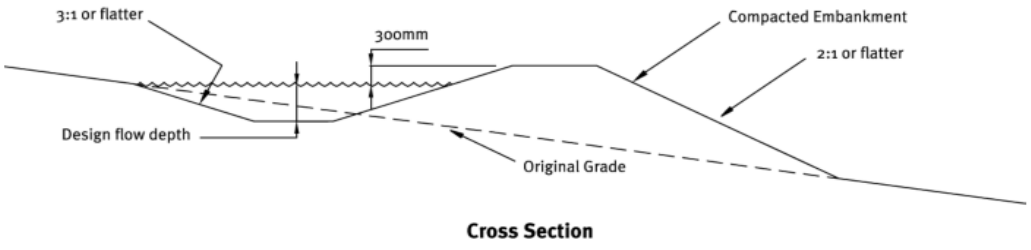


Figure 27: GD05 DWDC typical detail



Figure 28: DWDC with establishing direct-drilled grass. When all of the catchment and the channel itself is fully stabilised, it will become a clean water diversion



Figure 29: DWDC with rock check dams

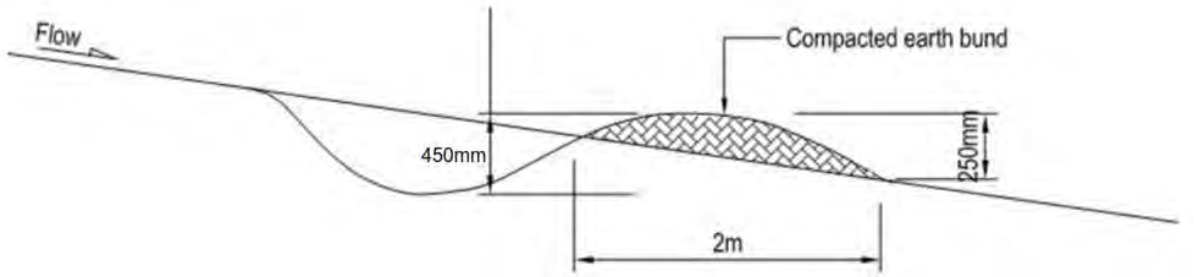
Key design criteria for CWDs are as follows:

- Ensure bunds are compacted and a shallow grade – at least 2:1 or flatter
- The upslope batter into the channel needs to be 3:1 or flatter – the flatter the channel batters are, the less likely they are to scour or fail

- Formally design diversion channels where catchments exceed 5 ha, ensuring they have capacity to carry the 5% AEP storm plus 300 mm freeboard
- Consider lining channels where gradients exceed 2% - however check dams can also help reduce flow velocities and scour in steeper drains.

Trafficable contour bund – GD05 pgs 47-50

Contour drains or contour bunds are constructed parallel to the contour to break up flowpaths, reduce slope catchments and minimise runoff velocities. Bunds need to be well-compacted, low and wide, to ensure heavy machinery can track over the bunds without damaging them. A shallow drain it to be formed on the upslope side of the bund.



Cross-section

Due to the virtually flat gradient of most of earthworks Areas 1-3, contour bunds can be installed every 50 to 100 m, and adjusted to suit vehicle movements and site needs.

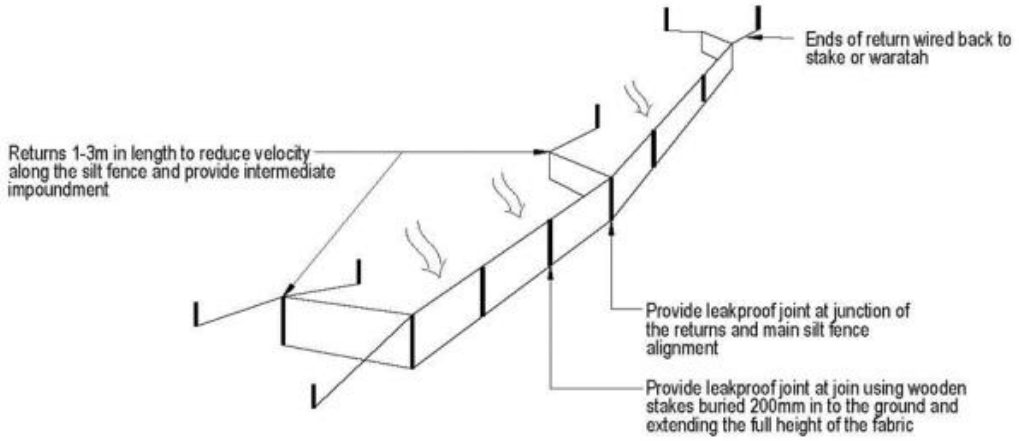
Silt fencing GD05 pgs 111-118

Silt fences are very effective perimeter sediment controls when installed correctly, however they are not designed to treat concentrated flows, and should only be relied on as a final element in a runoff treatment train – not a standalone ESC solution. For larger catchments, super silt fences provide more robust sediment control.

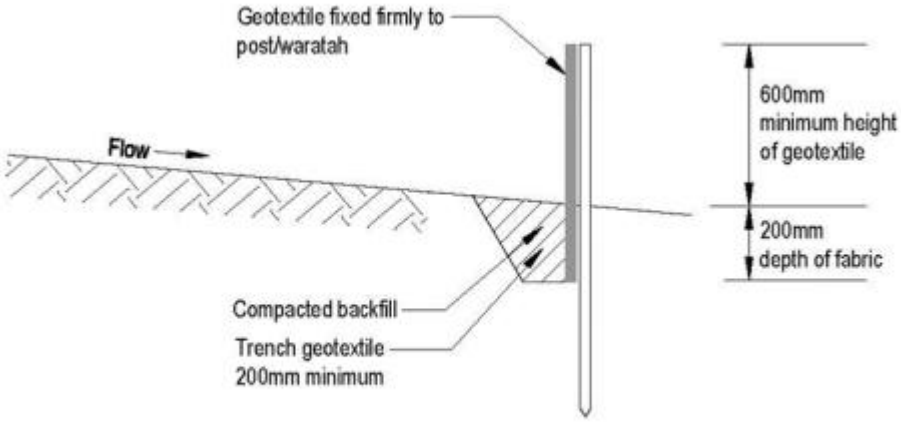
Key design criteria for installing silt fencing is as follows:

- Ensure silt fence height is 600 mm above ground level and 200 mm below ground level.
- Install silt fence **parallel to contours** to avoid formation of low points, where runoff can collect and destabilise the fence.

- Locate supporting posts/waratahs for silt fences 2-4 m apart with support provided by a tensioned wire (2.5 mm HT) along the top of the silt fence.
- Join lengths of silt fence by doubling over fabric ends around a waratah or by stapling the fabric ends to a batten and butting the two battens together.



Silt fence with returns and support wire



Cross-section

- For standard silt fences, use Table 13 (below) to determine maximum slope length, return spacing and maximum silt fence length based on contributing slope steepness.
- For super silt fences, use Table 14, below, for slope length, return spacing and max fence length.

Table 13: Silt fence design criteria

Slope steepness %	Slope length (m) (maximum)	Spacing of returns (m)	Silt fence length (m) (maximum)
Flatter than 2%	Unlimited	N/A	Unlimited
2 – 10%	40	60	300
10 – 20%	30	50	230
20 – 33%	20	40	150
33 – 50%	15	30	75
> 50%	6	20	40

Table 14: Super silt fence design criteria

Slope steepness %	Slope length (m) (maximum)	Spacing of returns (m)	Super silt fence length (m) (maximum)
0 – 10%	Unlimited	60	Unlimited
10 – 20%	60	50	450
20 – 33%	30	40	300
33 – 50%	30	30	150
> 50%	15	20	75



Figure 30: Super silt fence treating dirty upslope water

Silt socks – GD05 pgs 125-129

Silt socks are a tubular runoff sediment control consisting of either a mesh tube filled with filter material (e.g. compost, sawdust) or a log composed entirely of coconut fibre (coir log). They are used to intercept and slow sediment-laden runoff for smaller catchments, and (in the case of completely biodegradable products like coir logs) can be left to degrade into soil over time and/or be directly seeded to provide vegetated filtration bunds or check dams.







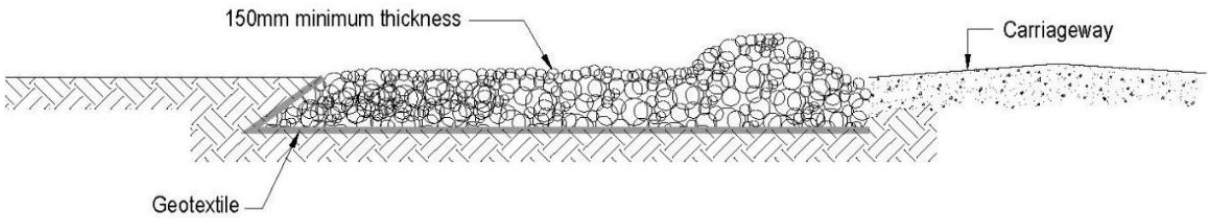
Key design criteria for installing silt socks includes:

- install socks/logs flush with the ground, to prevent runoff from flowing under the device. Where necessary, prepare the ground first to ensure 100% contact.
- similar to silt fencing, socks/logs should be installed parallel to the contour
- for perimeter control, ensure there is sufficient overlap with the next sock so that runoff can't flow in between the socks
- for 300 mm diameter silt socks, install as indicated below:

Slope steepness (%)	Maximum slope length (m)	Spacing of returns (m)
Flatter than 2%	100	N/A
2% - 10%	40	30
10% - 20%	30	25

Stabilised construction entrance – GD05 pgs 60-64

SCEs provide a stabilised access and egress point for construction/earthworks sites that is designed to vibrate/shake mud and dirt off wheels and minimise the amount of dirt tracked onto public roads, along with keeping dust to a minimum. To be effective, they must be regularly maintained/refurbished as mud begins to accumulate between the aggregate. For sites with mud issues or a high volume of traffic entering and exiting the site, combining an SCE with a series of trackout mats can be effective.



Side elevation

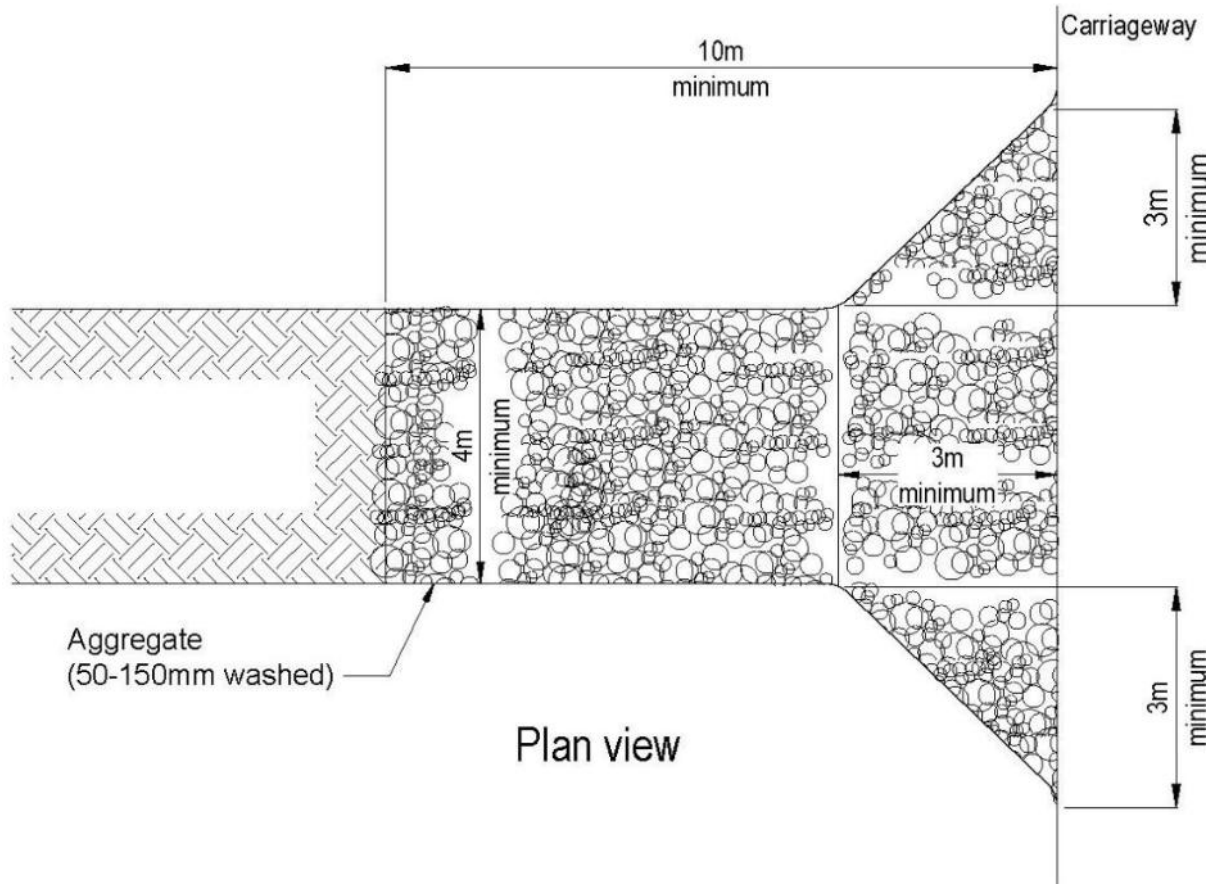


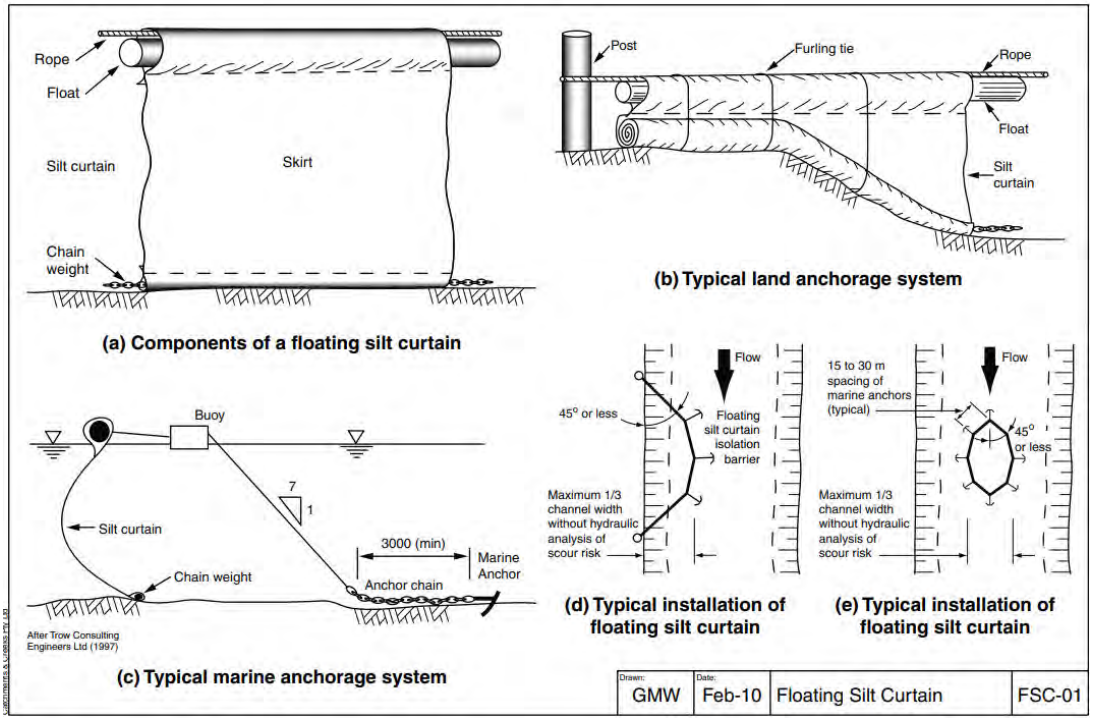
Figure 31: SCE design - section (above) and plan view (below)



Figure 32: Combination of trackout mats and SCE at site entrance

<u>Silt curtains</u>

A specification for silt curtains in relation to the cove construction in-water works will be developed in association with a domestic supplier of this specialised equipment. The below specification is taken from the IECA's Best Practice Erosion and Sediment Control (BPESC) manual, and is provided for indicative purposes only – noting that the specific design for the proposed applications will likely vary from that specified below.





Appendix F: Infiltration basin and diversion drain calculations

Infiltration basin Identifier: **IB1**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	1.8			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	220			m	Longest flow path within contributing catchment
Slope gradient (longest)	**6.36**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel	Sloping gravel			
% cover	92%	8%			Flat gravel interspersed with small areas of sloping gravel at quarry level interfaces.
Runoff coefficient (C)	0.15	0.25			From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59	2.59		mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	1.66	0.14		ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0018	0.0003		m^3/s	
IB design calculations					
Hourly volume required	6.4	0.9	**7.4**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	154.5	22.4	**176.9**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175	175	**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	36.8	5.3	**42.1**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (hrs)
Top length (A)			45.00	m	
Top width (B)			11.25	m	
Basal length (a)			38.00	m	
Basal width (b)			4.25	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			228.0	m^3	
Actual basal infiltration area			161.5	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			28.9	%	~29% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	1:5 batters with 1 m wide forebay flat bottom
Length			11.25	m	Full width of basin
Level spreader					
Width			11.25	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			4.25	m	Full width of the IB base

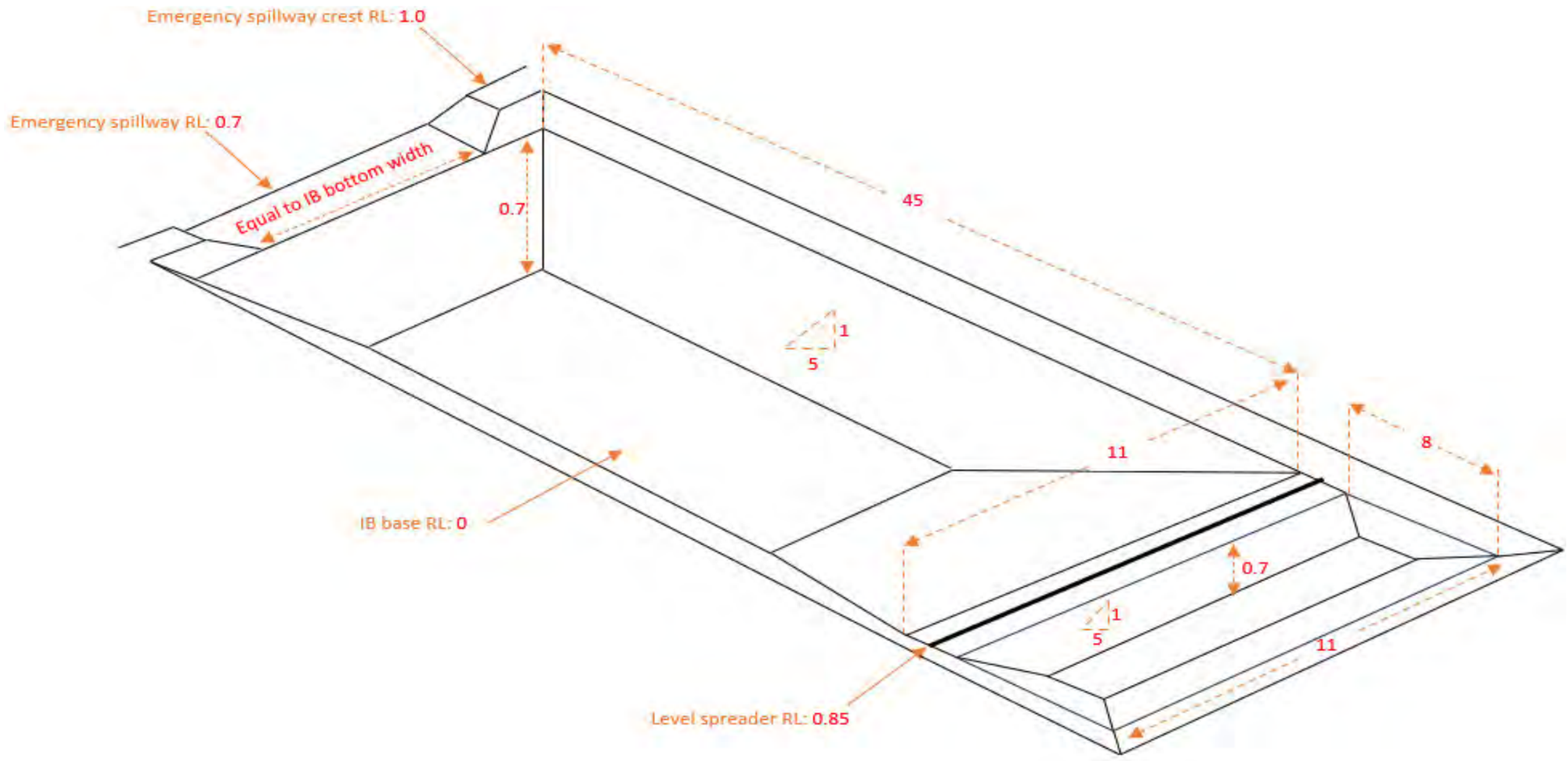
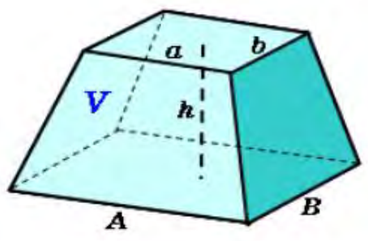


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	45	m	Pond volume calc:
B	11.25	m	**228.00**
a	38.00	m	
b	4.25	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB2**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	4.41			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	220			m	Longest flow path within contributing catchment
Slope gradient (longest)	**6.82**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel	Sloping gravel			
% cover	87%	13%			Flat gravel interspersed with small areas of sloping gravel at quarry level interfaces.
Runoff coefficient (C)	0.15	0.25			From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59	2.59		mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	3.83	0.58		ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0041	0.0010		m^3/s	
IB design calculations					
Hourly volume required	14.9	3.8	**18.6**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	357.4	90.2	**447.6**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175	175	**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	85.1	21.5	**106.6**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (hrs)
Top length (A)			60.00	m	
Top width (B)			15.00	m	
Basal length (a)			53.00	m	
Basal width (b)			8.00	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			457.7	m^3	
Actual basal infiltration area			424.0	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			2.3	%	~2% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	1:5 batters with 1 m wide forebay flat bottom
Length			15.00	m	Full width of basin
Level spreader					
Width			15.00	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			8.00	m	Full width of the IB base

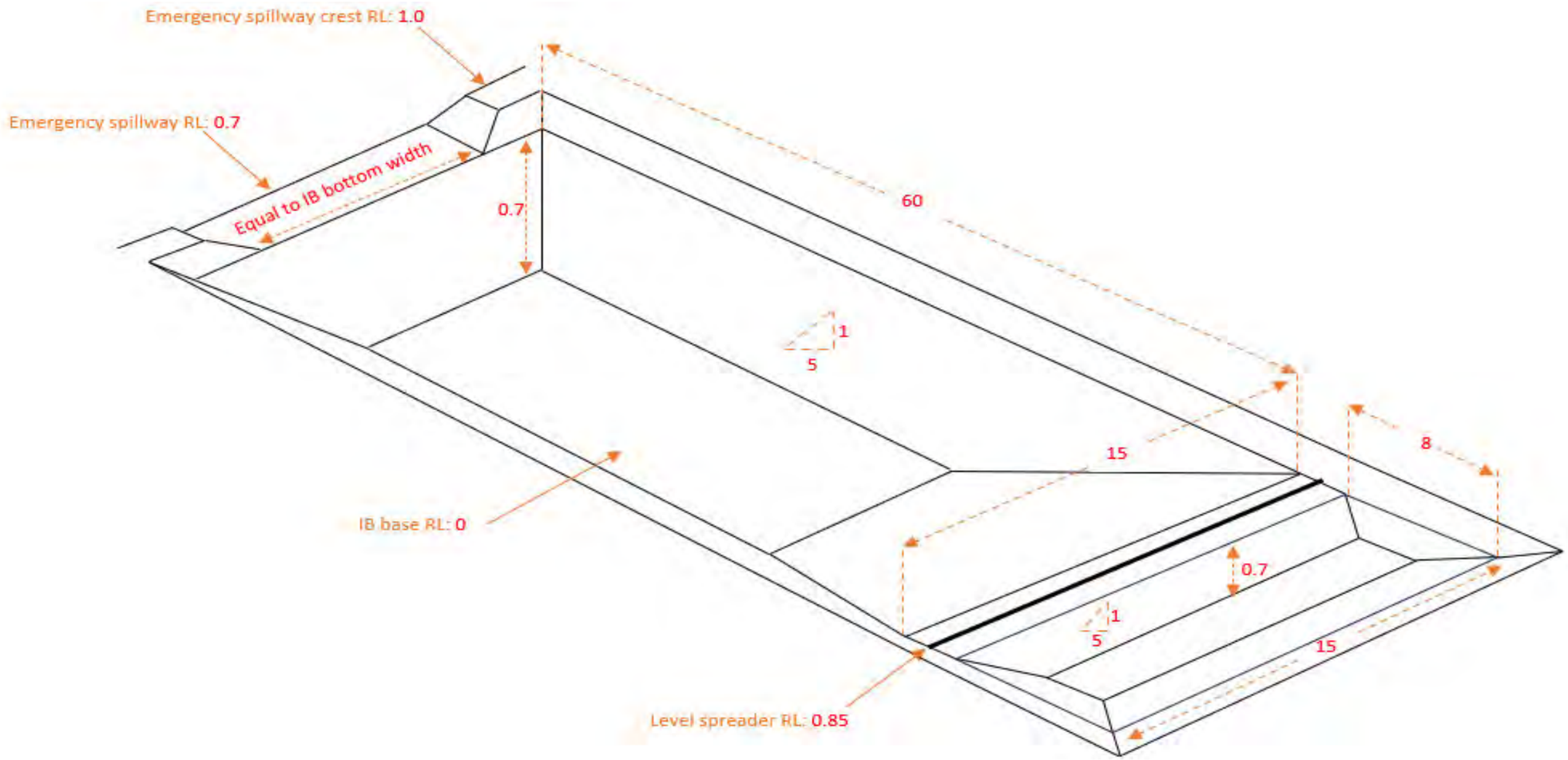
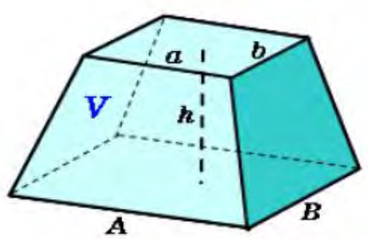


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	60	m	Pond volume calc:
B	15.00	m	**457.68**
a	53.00	m	
b	8.00	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB3**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	13.68			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	482			m	Longest flow path within contributing catchment
Slope gradient (longest)	**3.73**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel	Sloping gravel			
% cover	66%	34%			
Runoff coefficient (C)	0.15	0.25			From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59	2.59		mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	8.97	4.710677196		ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0097	0.0085		m^3/s	
IB design calculations					
Hourly volume required	34.9	30.5	**65.4**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	837.0	732.6	**1569.6**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175	175	**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	199.3	174.4	**373.7**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (24 hrs)
Top length (A)			104.00	m	
Top width (B)			26.00	m	
Basal length (a)			97.00	m	
Basal width (b)			19.00	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			1585.7	m^3	
Actual basal infiltration area			1843.0	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			1.0	%	~1% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	
Length			26.00	m	Full width of basin
Level spreader					
Width			26.00	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			19.00	m	Full width of the IB base

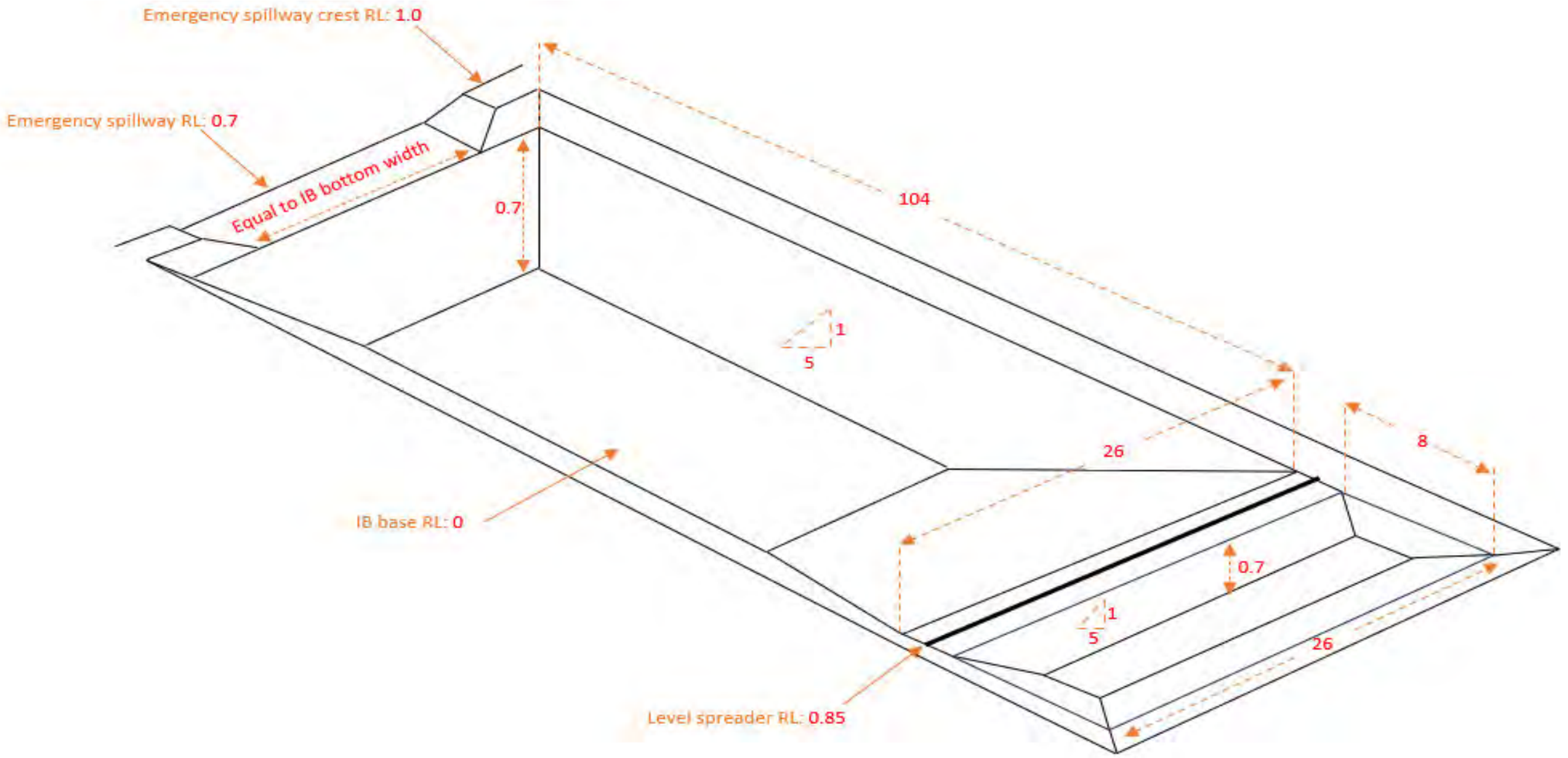
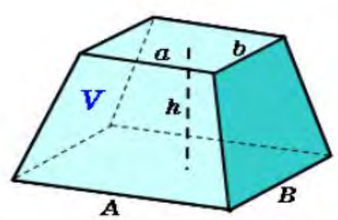


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	104	m	Pond volume calc:
B	26.00	m	**1585.73**
a	97.00	m	
b	19.00	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB4**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	4.63			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	284			m	Longest flow path within contributing catchment
Slope gradient (longest)	**1.41**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel				
% cover	100%				
Runoff coefficient (C)	0.15				From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59			mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	4.63			ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0050			m^3/s	
IB design calculations					
Hourly volume required	18.0		**18.0**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	432.0		**432.0**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175		**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	102.9		**102.9**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (24 hrs)
Top length (A)			60.00	m	
Top width (B)			15.00	m	
Basal length (a)			53.00	m	
Basal width (b)			8.00	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			457.7	m^3	
Actual basal infiltration area			424.0	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			5.9	%	~6% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	
Length			15.00	m	Full width of basin
Level spreader					
Width			15.00	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			8.00	m	Full width of the IB base

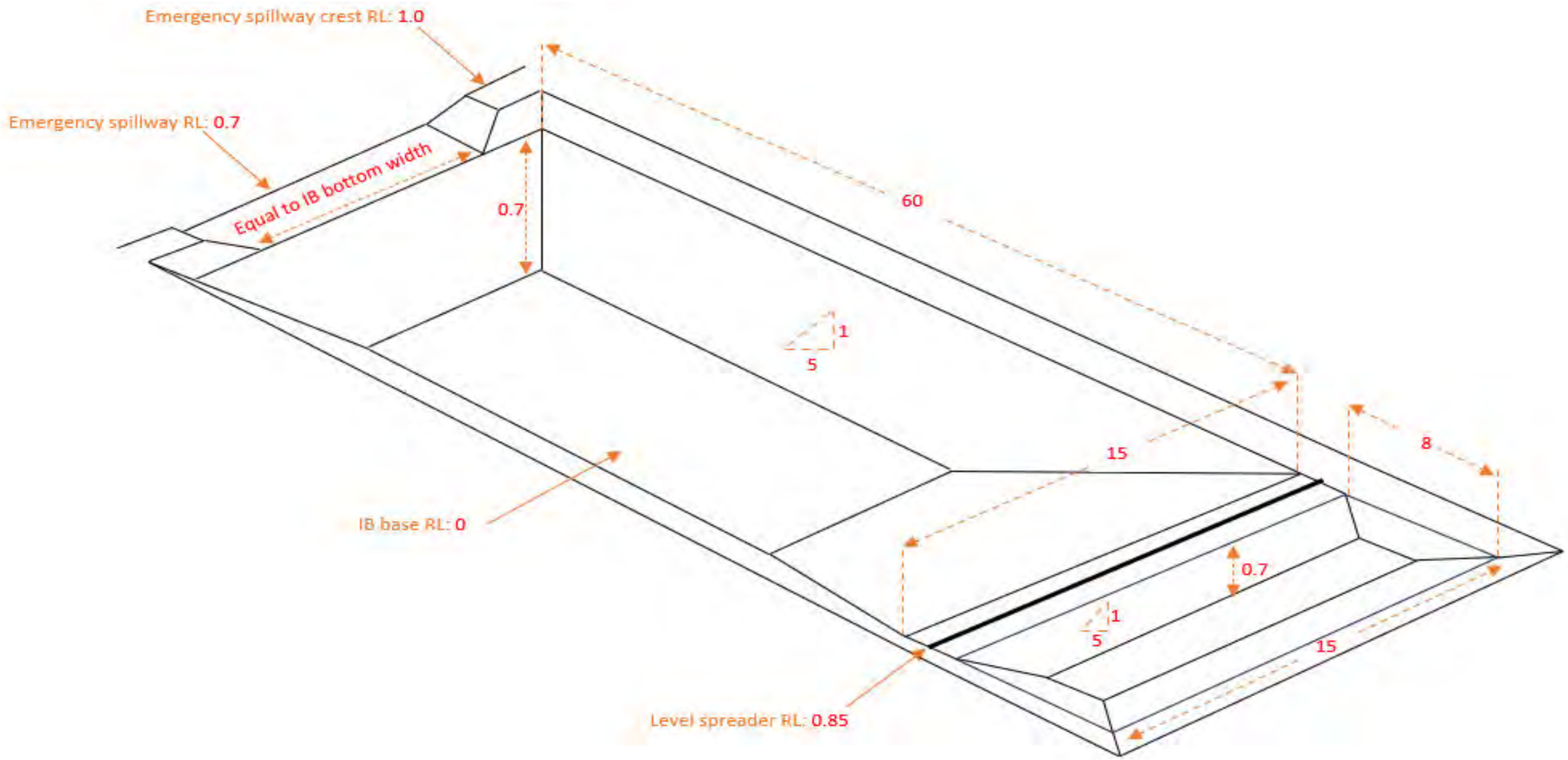
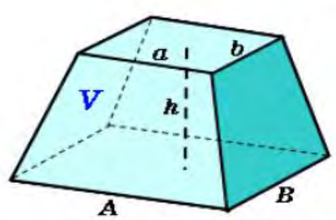


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	60	m	Pond volume calc:
B	15.00	m	**457.68**
a	53.00	m	
b	8.00	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB5**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	6.03			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	311			m	Longest flow path within contributing catchment
Slope gradient (longest)	**0.32**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel				
% cover	100%				
Runoff coefficient (C)	0.15				From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59			mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	6.03			ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0065			m^3/s	
IB design calculations					
Hourly volume required	23.4		**23.4**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	562.7		**562.7**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175		**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	134.0		**134.0**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (24 hrs)
Top length (A)			66.00	m	
Top width (B)			16.50	m	
Basal length (a)			59.00	m	
Basal width (b)			9.50	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			571.6	m^3	
Actual basal infiltration area			560.5	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			1.6	%	~2% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	
Length			16.50	m	Full width of basin
Level spreader					
Width			16.50	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			9.50	m	Full width of the IB base

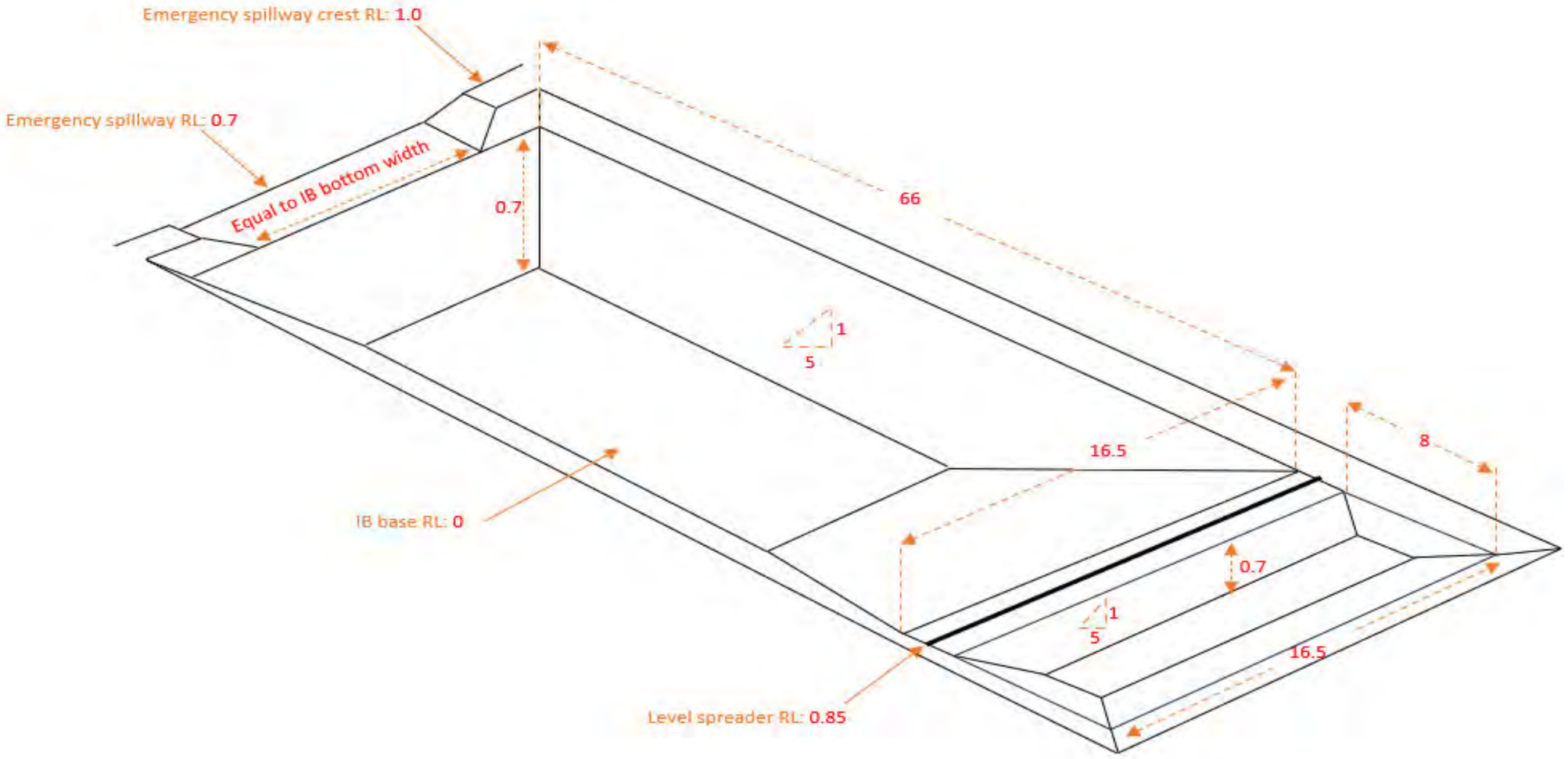
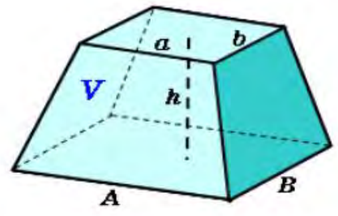


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	66	m	Pond volume calc:
B	16.50	m	**571.61**
a	59.00	m	
b	9.50	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB6**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	36.09			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	650			m	Longest flow path within contributing catchment
Slope gradient (longest)	**0.46**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel	Flat grass			
% cover	25%	75%			Flat gravel within the active works area; flat grass underlain by topsoil and then compacted fill for rest
Runoff coefficient (C)	0.15	0.2			From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59	2.59		mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	8.91	27.18		ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0096	0.0391		m^3/s	
IB design calculations					
Hourly volume required	34.6	140.9	**175.5**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	831.4	3381.7	**4213.2**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175	175	**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	198.0	805.2	**1003.1**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (hrs)
Top length (A)			166.00	m	
Top width (B)			41.50	m	
Basal length (a)			159.00	m	
Basal width (b)			34.50	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			4325.4	m^3	
Actual basal infiltration area			5485.5	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			2.7	%	~3% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			10.00	m	1:5 batters with 3 m wide forebay flat bottom
Length			41.50	m	Full width of basin
Level spreader					
Width			41.50	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			34.50	m	Full width of the IB base

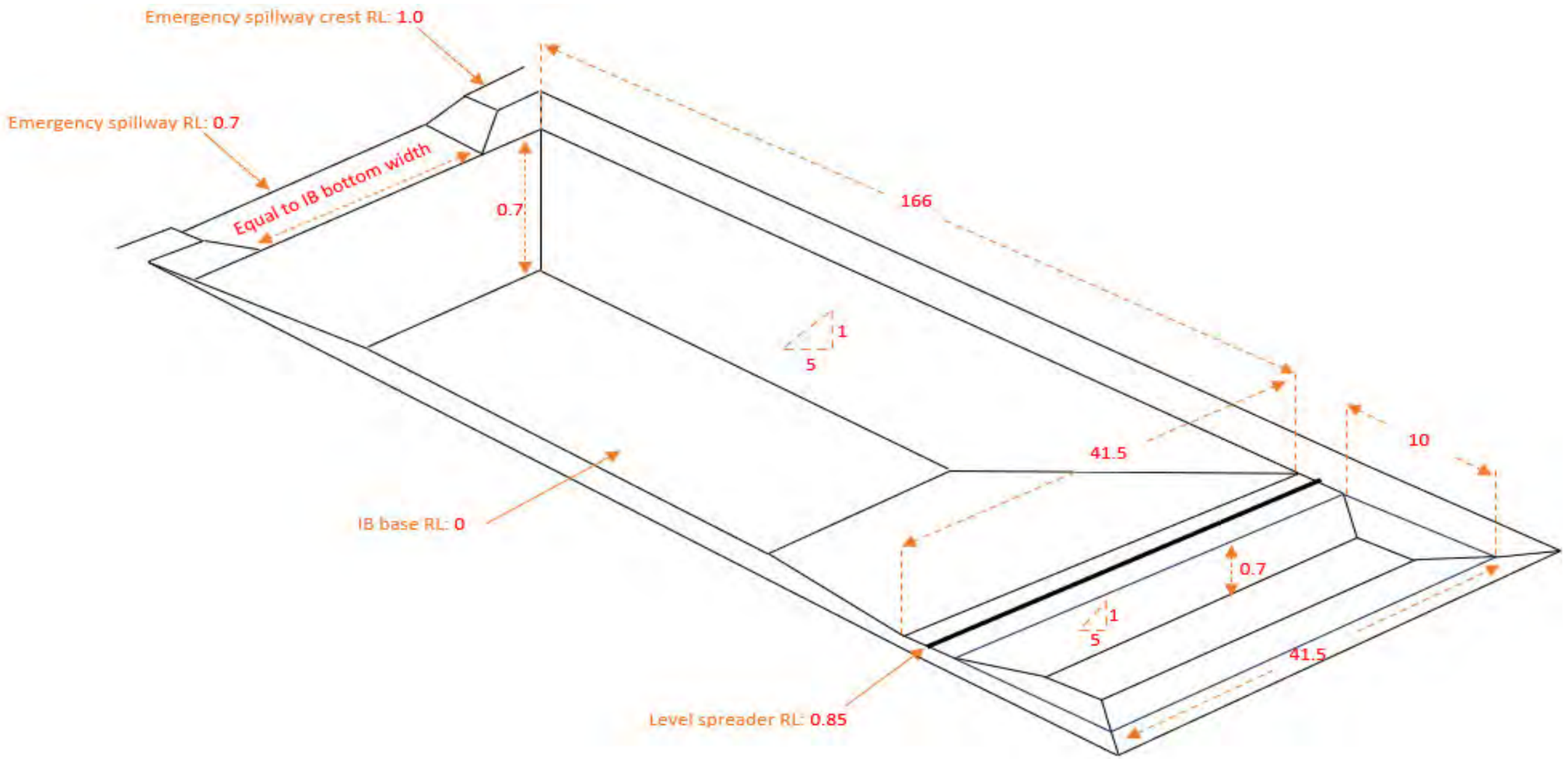
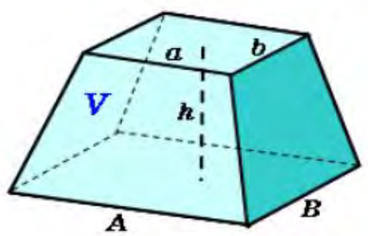


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	166	m	Pond volume calc:
B	41.50	m	**4325.36**
a	159.00	m	
b	34.50	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB7**

Input	Value 1	Value 2		Total/design	Units	Notes / Reference
Catchment information						
Contributing catchment	12.58				ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	800				m	Longest flow path within contributing catchment
Slope gradient (longest)	**1.88**				%	
Slope gradient (immediately upslope)	0.50				**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24				months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation						Q = 0.00278CiA
Catchment ground cover	Flat gravel	Sloping gravel	Flat grass			
% cover	58%	12%	30%			Flat gravel within the active works area; flat grass underlain by topsoil and then compacted fill for rest
Runoff coefficient (C)	0.15	0.25	0.2			From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59	2.59	2.59		mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	7.27	1.51	3.80		ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0079	0.0027	0.0055		m^3/s	
IB design calculations						
Hourly volume required	28.3	9.8	19.7	**48.0**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	678.4	234.8	472.8	**1386.0**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175	175	175	**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	161.5	55.9	112.6	**330.0**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (hrs)
Top length (A)				100.00	m	
Top width (B)				25.00	m	
Basal length (a)				93.00	m	
Basal width (b)				18.00	m	
Depth (h)				0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio				1:5	rise/run	1:5 ratio as not space limited. Reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)				1455.2	m^3	
Actual basal infiltration area				1674.0	m^2	
Length-width ratio				4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer				5.0	%	~5% additional storage above minimum storage required (not including infiltration capacity)
Forebay						
Depth				0.7	m	
Width				8.00	m	1:5 batters with 1 m wide forebay flat bottom
Length				25.00	m	Full width of basin
Level spreader						
Width				25.00	m	Must span full width of basin
Height above emergency spillway invert				0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient				1:5	rise/run	
Emergency spillway						
Spillway invert depth from crest				0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width				18.00	m	Full width of the IB base

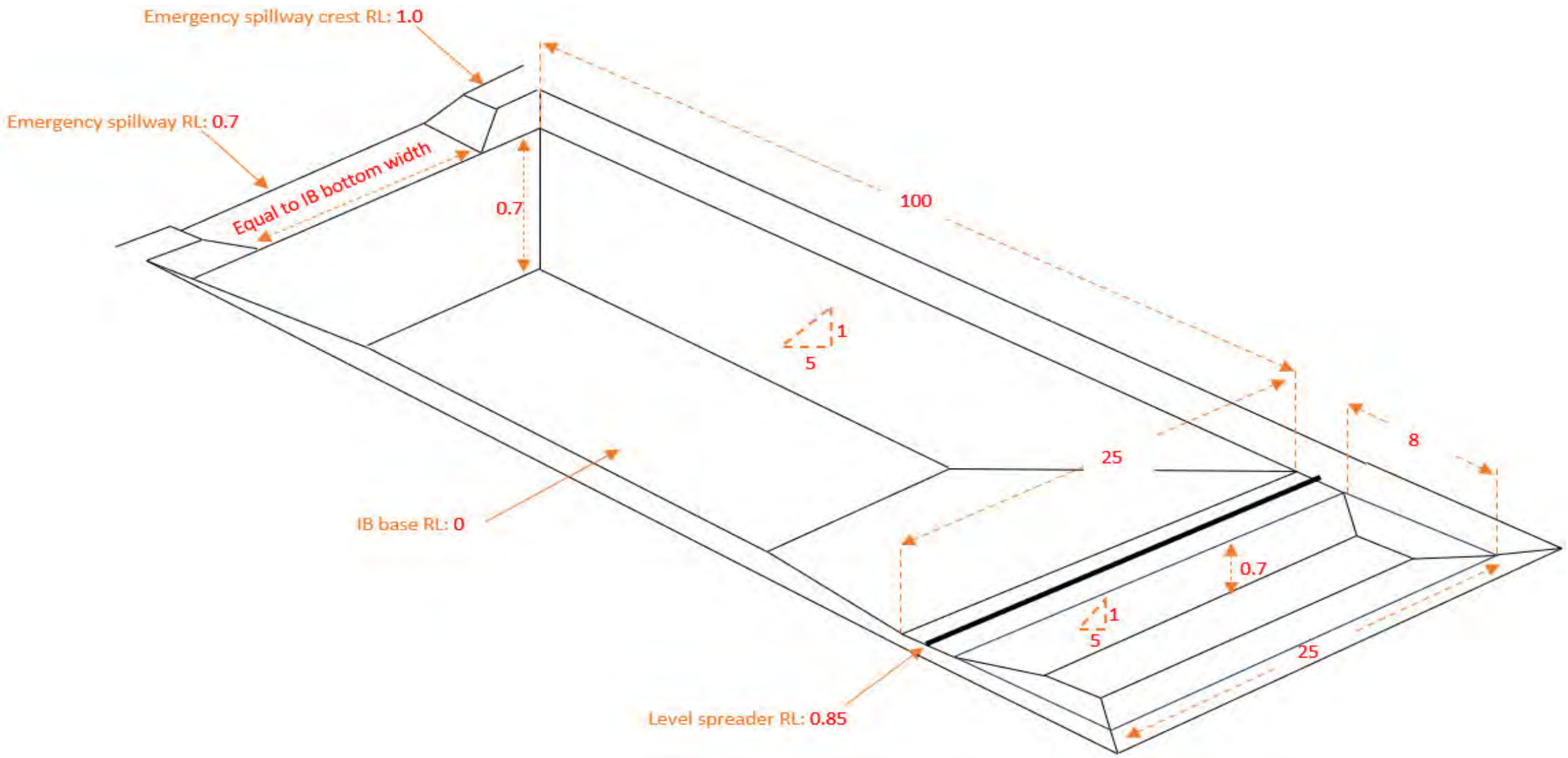
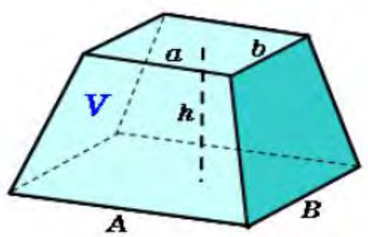


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	100	m	Pond volume calc:
B	25.00	m	**1455.18**
a	93.00	m	
b	18.00	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Infiltration basin Identifier: **IB8**

Input	Value 1	Value 2	Total/design	Units	Notes / Reference
Catchment information					
Contributing catchment	2.11			ha	Based on project shapefiles and assumed ESC installations
Slope length (longest flow path)	141			m	Longest flow path within contributing catchment
Slope gradient (longest)	**0.71**			%	
Slope gradient (immediately upslope)	0.50			**%**	Greater of slope immediately (within 20 m) above IB OR average slope over contributing catchment
Project duration	24			months	Assumed worst case for Area 1 works until 80%+ stabilisation achieved
Peak runoff calculation					Q = 0.00278CiA
Catchment ground cover	Flat gravel				
% cover	100%				
Runoff coefficient (C)	0.15				From NZTA ESC Guidelines Table 6.5
Rainfall (i)	2.59			mm/hr	HIRDS V4 'Northburn' 5% AEP (20-year ARI), 24-hr duration
Catchment area (A)	2.11			ha	Assumed catchment based on prelim design
Peak runoff flow (Q)	0.0023			m^3/s	
IB design calculations					
Hourly volume required	8.2		**8.2**	m^3	Based on accumulated peak runoff flow over 1 hour
24-hour volume required	196.9		**196.9**	m^3	Based on accumulated peak runoff flow over 24 hours
Assumed infiltration rate	175		**175**	mm/hr	Based on indicative soakage testing within the catchment
Minimum basal area required	46.9		**46.9**	m^2	Calculated via A=V/ft, where V = infiltration volume (m^3), f = infiltration rate (m/hr) and t = time (24 hrs)
Top length (A)			44.00	m	
Top width (B)			11.00	m	
Basal length (a)			37.00	m	
Basal width (b)			4.00	m	
Depth (h)			0.7	m	Shallow to enable easy maintenance and avoid high water table
Internal batter ratio			1:5	rise/run	1:5 ratio reduces scour and stability risk and is trafficable if needed
Calculated actual volume (V)			215.5	m^3	
Actual basal infiltration area			148.0	m^2	
Length-width ratio			4:1	ratio	Ratio must be ≥3:1 & ≤5:1, measured at height of primary spillway
Additional storage buffer			9.4	%	~9% additional storage above minimum storage required (not including infiltration capacity)
Forebay					
Depth			0.7	m	
Width			8.00	m	1:5 batters with 1 m wide forebay flat bottom
Length			11.00	m	Full width of basin
Level spreader					
Width			11.00	m	Must span full width of basin
Height above emergency spillway invert			0.15	m	Must be 0.1 - 0.2 m above emergency spillway invert
Downstream inlet batter gradient			1:5	rise/run	
Emergency spillway					
Spillway invert depth from crest			0.3	m	Minimum 0.3 m below top of IB embankment
Spillway bottom width			4.00	m	Full width of the IB base

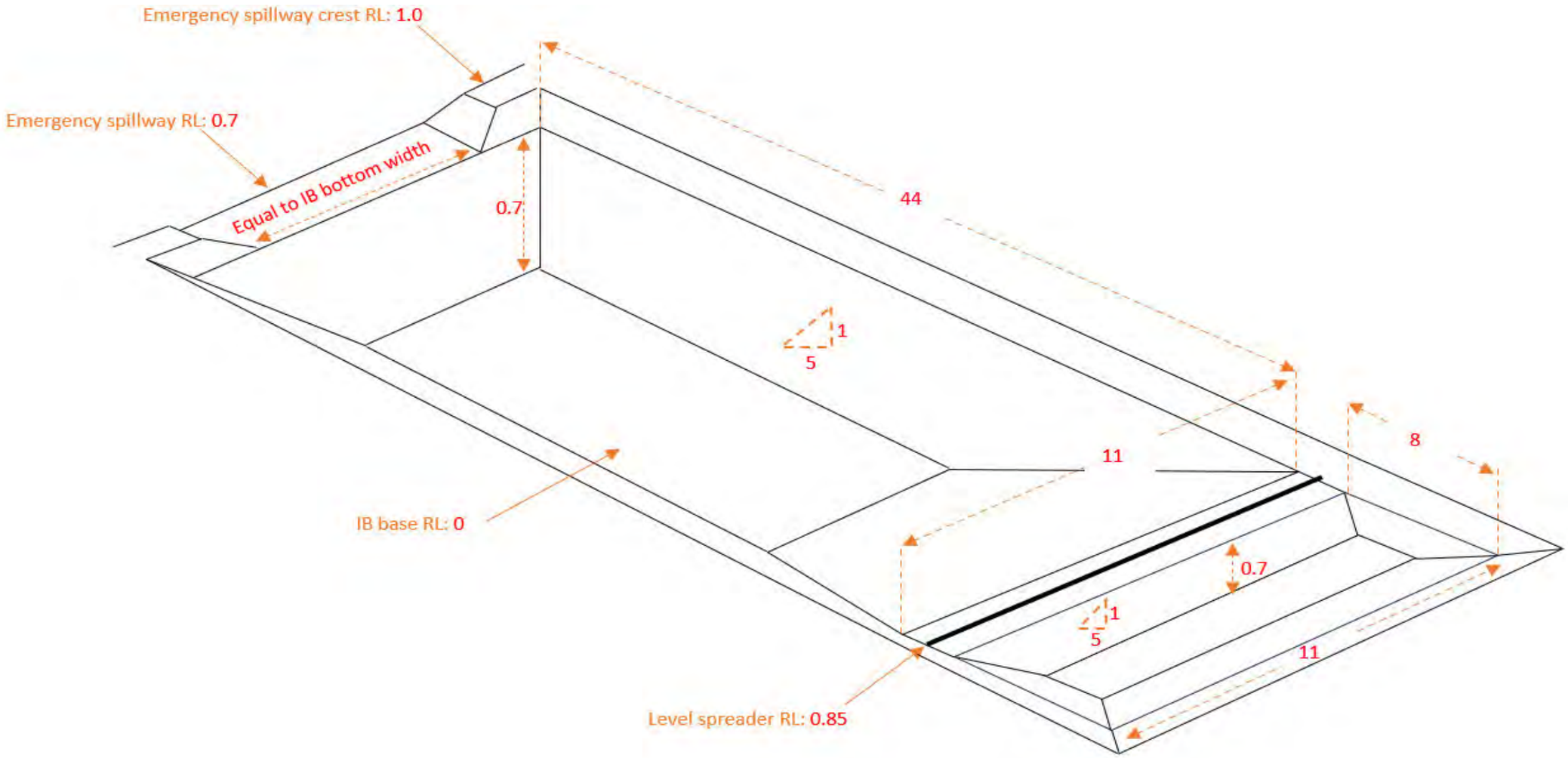
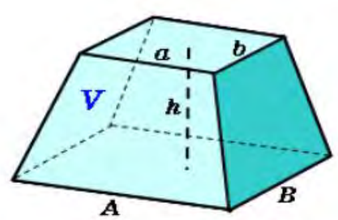


Table 6.5 Representative C values for different soil types and slope (Environment Canterbury, 2007)

Soil types/slope	C factor
Flat gravel (<5%)	0.15
Sloping gravel (>10%)	0.25
Flat silt loam (<5%)	0.3
Sloping silt loam (10-20%)	0.4
Steep silt loam (>20%)	0.5
Clay (<10%)	0.65
Clay (>10%)	0.75

IB dimensions at emergency spillway invert

A	44	m	Pond volume calc:
B	11.00	m	**215.48**
a	37.00	m	
b	4.00	m	
h	0.7	m	



Obelisk

(1) *volume* : $V = \frac{h}{6}(Ab + aB + 2(ab + AB))$

Indicative DWDC and CWDC design

Swale drains to: IB6 (DWDC) & Area 4c & 4b southern (CWDC)

	DWDC	CWDC
Catchment area (ha)	36.09	6.00
Catchment flowpath length (m)	450	229
Catchment elevation fall (m)	4	6
Gradient (%)	0.9	2.6
Retardance coefficient (N)*	0.01	0.01

*Representative of smooth, packed gravel

Conveyance capacity requirements: 5% AEP storm plus 300 mm freeboard (assumed)

5% AEP rainfall intensity calculations

DWDC catchment	DWDC	CWDC	Unit
Area	36.09	6	ha
Rainfall intensity (10 min duration)*	44.5	44.5	mm/hour

*Based on hirds.niwa.co.nz for Site ID: NORTHBURN

source: https://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/appendixa.pdf

Peak runoff calculations

Using Rational Method: Q = CiA/360

	DWDC	CWDC	Unit
C (runoff coefficient)	0.55	0.55	N/A
i (rainfall intensity)	44.5	44.5	mm/hour
A (catchment area)	36.09	6	ha
Q (peak flow)	2.4536	0.4079	m^3/s

Generally flat, compacted gravels

Calculate channel design

Using Manning's Formula Trapezoidal Channel Flow calculator

Roughness coefficient (n): 0.025 (Earth, gravelly)

	DWDC	CWDC	Unit
Channel flow path (length)	360	548	m
Elevation fall	2	4	m
Slope	0.6	0.7	%

Source: https://www.engineeringtoolbox.com/mannings-roughness-d_799.html

RUNOFF COEFFICIENTS FOR THE RATIONAL FORMULA

Typical Composite Runoff Coefficients by Land Use		Normal Range of Runoff Coefficients	
Area Description	C-value	Surface Characteristic	C-value
Business		**Lawns**	
Downtown Areas	0.70-0.95	Sandy Soil, Flat (2%)	0.05-0.10
Neighborhood Areas	0.50-0.70	Sandy Soil, Ave. (2-7%)	0.10-0.15
		Sandy Soil, Steep (>7%)	0.15-0.20
Residential		Heavy Soil, Flat (2%)	0.13-0.17
Single Family Areas	0.30-0.50	Heavy Soil, Ave. (2-7%)	0.18-0.22
Multi-Units (detached)	0.40-0.60	Heavy Soil, Steep (>7%)	0.2500.35
Multi-Units (attached)	0.60-0.75		
Suburban	0.25-0.40	**Agricultural**	
Apartments	0.50-0.70	Bare Packed Soil	
		Smooth	0.30-0.60
Industrial		Rough	0.20-0.50
Light Use	0.50-0.80	Cultivated Rows	
Heavy Use	0.60-0.90	Heavy Soil, no crop	0.30-0.60
Railroad Yards	0.20-0.35	Heavy Soil, with crop	0.20-0.50
Unimproved Areas	0.10-0.30	Sandy Soil, no crop	0.20-0.40
		Sandy Soil, with crop	0.10-0.25
Park		Pasture	
Park/Cemeteries	0.10-0.25	Heavy Soil	0.15-0.45
Playgrounds	0.20-0.35	Sandy Soil	0.05-0.25
Pavement		**Woodland**	0.05-0.25
Asphalt and Concrete	0.70-0.95		
Brick	0.70-0.85		
Roof	0.75-0.95		

The presented C-values are typical for return periods of 2-10-year storms with the higher values for the larger design storms. Judgement must be used to select the appropriate C-value within the range for the land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have the lower C-value; and smaller areas with low permeability soils, steep slopes and sparse vegetation should be assigned higher a C-value.

Surface Material	Manning's Roughness Coefficient - *n* -
Asbestos cement	0.011
Asphalt	0.016
Brass	0.011
Brick and cement mortar sewers	0.015
Canvas	0.012
Cast or Ductile iron, new	0.012
Clay tile	0.014
Concrete - steel forms	0.011
Concrete (Cement) - finished	0.012
Concrete - wooden forms	0.015
Concrete - centrifugally spun	0.013
Copper	0.011
Corrugated metal	0.022
Earth, smooth	0.018
Earth channel - clean	0.022
Earth channel - gravelly	0.025
Earth channel - weedy	0.030
Earth channel - stony, cobbles	0.035
Floodplains - pasture, farmland	0.035
Floodplains - light brush	0.050
Floodplains - heavy brush	0.075
Floodplains - trees	0.15
Galvanized iron	0.016
Glass	0.010
Gravel, firm	0.023
Lead	0.011
Masonry	0.025
Metal - corrugated	0.022
Natural streams - clean and straight	0.030
Natural streams - major rivers	0.035
Natural streams - sluggish with deep pools	0.040
Natural channels, very poor condition	0.060
Plastic	0.009
Polyethylene PE - Corrugated with smooth inner walls	0.009 - 0.015
Polyethylene PE - Corrugated with corrugated inner walls	0.018 - 0.025
Polyvinyl Chloride PVC - with smooth inner walls	0.009 - 0.011

Sizing calculations for DWDC:

Inputs

Bottom width, b	2	m	X
Side slope 1 (horiz./vert.)	3		X
Side slope 2 (horiz./vert.)	3		X
Manning roughness, n ? ○Strickler ○B/B (See notes)	0.025		X
Channel slope, S	1	% rise/run	X
Flow depth, y	0.43	m	X

Results

Flow area, a	1.4147	m^2	X
Wetted perimeter, P_w	4.7196	m	X
Hydraulic radius, R_h	0.2998	m	X
Velocity, v	1.7916	m/s	X
Flow, Q	2.5345	m^3/s	X
Velocity head, h_v	0.1637	m	X
Top width, T	4.5800	m	X

Thus with a bottom width of 2m, side slopes of 3:1, and a design flow depth of 0.43 m,
flow capacity of 2.53 m^3/s is achieved. This exceeds the 2.45 m^3/s design flow for the DWDC.

Sizing calculations for CWDC:

Inputs

Bottom width, b	1	m	X
Side slope 1 (horiz./vert.)	3		X
Side slope 2 (horiz./vert.)	3		X
Manning roughness, n ? ○Strickler ○B/B (See notes)	0.025		X
Channel slope, S	1	% rise/run	X
Flow depth, y	0.25	m	X

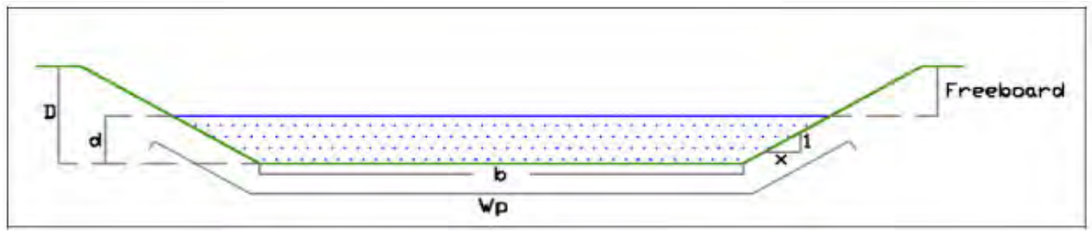
Results

Flow area, a	0.4375	m^2	X
Wetted perimeter, P_w	2.5811	m	X
Hydraulic radius, R_h	0.1695	m	X
Velocity, v	1.2251	m/s	X
Flow, Q	0.5360	m^3/s	X
Velocity head, h_v	0.0765	m	X
Top width, T	2.5000	m	X

Thus with a bottom width of 1m, side slopes of 3:1, and a design flow depth of 0.25 m,
flow capacity of 0.54 m^3/s is achieved. This exceeds the 0.41 m^3/s design flow for the DWDC.

Summary of dimensions for all swales

	Swale 1	Swale 2	Unit
Bottom width (b)	2	1	m
Side slope gradient	3	3	H:V
Effective depth (d)	0.43	0.25	m
Depth + 300 mm freeboard (D)	0.73	0.55	m
Average channel slope	0.6	0.7	%
Flow capacity (Q)	2.5300	0.5400	m^3/s
Q (peak flow)	2.4536	0.4079	m^3/s



Appendix G: Accidental Discovery Protocol

APPENDIX 4: HERITAGE NEW ZEALAND POUHERE TAONGA ARCHAEOLOGICAL DISCOVERY PROTOCOL

HERITAGE NEW ZEALAND
POUHERE TAONGA

Heritage New Zealand Pouhere Taonga Archaeological Discovery Protocol

Under the Heritage New Zealand Pouhere Taonga Act (2014) an archaeological site is defined as any place in New Zealand that was associated with human activity that occurred before 1900 and provides or may provide, through investigation by archaeological methods, evidence relating to the history of New Zealand. For pre-contact Maori sites this evidence may be in the form of bones, shells, charcoal, stones etc. In later sites of European/Chinese origin, artefacts such as bottle glass, crockery etc. may be found, or evidence of old foundations, wells, drains or similar structures. Burials/koiwi tangata may be found from any historic period.

In the event that an unidentified archaeological site is located during works, the following applies;

1. Work shall cease immediately at that place and within 20m around the site.
2. The contractor must shut down all machinery, secure the area, and advise the Site Manager.
3. The Site Manager shall secure the site and notify the Heritage New Zealand Regional Archaeologist. Further assessment by an archaeologist may be required.
4 If the site is of Maori origin, the Site Manager shall notify the Heritage New Zealand Regional Archaeologist and the appropriate iwi groups or kaitiaki representative of the discovery and ensure site access to enable appropriate cultural procedures and tikanga to be undertaken, as long as all statutory requirements under legislation are met (*Heritage New Zealand Pouhere Taonga Act*, *Protected Objects Act*).
5. If human remains (koiwi tangata) are uncovered the Site Manager shall advise the Heritage New Zealand Regional Archaeologist, NZ Police and the appropriate iwi groups or kaitiaki representative and the above process under 4 shall apply. Remains are not to be moved until such time as iwi and Heritage New Zealand have responded.
6. Works affecting the archaeological site and any human remains (koiwi tangata) shall not resume until Heritage New Zealand gives written approval for work to continue. Further assessment by an archaeologist may be required.
7. Where iwi so request, any information recorded as the result of the find such as a description of location and content, is to be provided for their records.
8. Heritage New Zealand will determine if an archaeological authority under the *Heritage New Zealand Pouhere Taonga Act* 2014 is required for works to continue.

It is an offence under S87 of the *Heritage New Zealand Pouhere Taonga Act 2014* to modify or destroy an archaeological site without an authority from Heritage New Zealand irrespective of

Appendix H: Parkburn soil permeability testing report

29 April 2026

Fulton Hogan Land Development Ltd
C/- Tim James
Via email: [redacted]
CC:

Re: Soil Permeability Testing, Parkburn Quarry

Our Reference: 24019_4

1 Introduction and Scope of Report

JKCM Ltd, trading as Insight Engineering (IE), was requested to arrange and observe three soil permeability tests at the Parkburn Quarry (herein referred to as 'the site'). The tests were requested to inform the erosion and sediment control plans for the future land development earthworks proposed to be carried out at the site.

This letter presents a brief description of the tests, calculations and a summary of results.

2 Soil Permeability Tests

2.1 Methodology

Three soil permeability tests were completed at the site on 24 April 2026. As the tests were arranged with short notice, we opted to use test pits, rather than boreholes or standpipes to complete the tests.

The test pits were excavated using a 1.8T excavator. Due to the relatively dense ground conditions, the test pits were all terminated at a depth of 0.6 m. The sides and base of the test pits were squared and cleaned as much as practicable prior to commencing the tests.

Each test pit was filled with water to approximately 100-150 mm below the top, with the water level measured from a fixed point.

It was not possible to pre-soak the test pits, however at Test 1, where the water drained away rapidly (in less than 10 minutes), the test was repeated three times. At Test 2 the rate at which the water drained was significantly slower than Test 1, and therefore the test was terminated after an hour when the remaining water depth was less than 0.25 m above the base of the pit.

At Test 3, the base of the test pit was approximately 0.5 to 1 m above the lake level (as estimated from information provided by Fulton Hogan quarry operators). The water was not observed to drain for a period of 45 minutes and therefore the test was terminated and no calculations were performed.

2.2 Test Pits

The locations of the three test pits are shown on the attached plan.

2.2.1 Test 1

The soil conditions encountered at Test 1 included 100mm of topsoil overlying dry, brown sandy, fine to coarse GRAVEL with some cobbles and trace silt. The gravel was observed to be loosely packed, well graded and sub-rounded to sub-angular.

2.2.2 Test 2

No topsoil was present at the location of Test 2. The test pit exposed dry, brownish-grey sandy, fine to coarse GRAVEL with some cobbles and trace silt and boulders. The gravel was observed to be tightly packed, well graded and sub-rounded to sub-angular.

2.2.3 Test 3

No topsoil was present at the location of Test 3. The test pit exposed dry, brownish-grey sandy, fine to coarse GRAVEL with some cobbles and trace silt and boulders. The gravel became wet at a depth of 0.3 m and was observed to be loosely to tightly packed, well graded and sub-rounded to sub-angular.

3 Results

3.1 Percolation/Infiltration Rates

Percolation/infiltration rates were calculated for Test 1 and Test 2 using two methods. The more conservative result for each are presented below. As discussed in the preceding section, no results were able to be calculated for Test 3 as the water did not soak away.

Calculation worksheets are attached to this letter.

Test 1

The calculated infiltration rate is 3.85 x 10^{-4} m/s or 1,380 mm/hr.

Test 2

The calculated infiltration rate is 4.9 x 10^{-5} m/s or 175 mm/hr.

3.2 Erodibility Factor K

We attempted to assess the erodibility factor K for the typical site materials based on observations in the field, as well as making some assumptions on the material properties. It must be noted that our assessment of this factor is limited and based on several assumptions of the soil properties. Therefore further laboratory or field testing may be required (noting that an emersion test and a specific sieve and hydrometer analysis has not been carried out yet).

Erodibility factor K is estimated using the Wischmeier and Smith nomograph.

$$100K = 2.1M^{1.14}(10^{-4})(12-a) + 3.25(b-2) + 2.5(c-3)$$

Where:
M = (%silt + %sand) x (100 - % clay)
a = % organic
b = soil structure code (taken as 2 in this case, fine granular)
c = soil permeability class (taken as 5 in this case, slow materials exposed by deep excavation of the quarry).

In this case, we estimated the percentage sand, silt and clay from a prior grading curve for pit run material sampled from the quarry (attached). Taking the percentage of sand as 13%, and assuming 1% for silt and clay respectively, the calculated M value is 1,287.

Therefore, the calculated K factor is 0.14 (US units) or 0.0182 (SI units).

We reiterate again that this factor is based on several assumptions and we strongly advise that this factor should be reviewed once further laboratory and/or field test data is available.

4 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Fulton Hogan Land Development Ltd, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground and material conditions indicated from published sources, inspections and tests described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site and material characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

Report prepared by



Jana Kruyshaar, CMEngNZ, MIPENZ
Principal Geotechnical Engineer

Appendix 1: Test Location Plan

Appendix 2: Soil Permeability Calculation Worksheets

Appendix 3: Laboratory Particle Size Distribution Result (Pit Run)

Appendix 1

Test Location Plan



Description	Soil Permeability Test Locations (Not to scale, for information only)		
Project	Parkburn Development	Date drawn	24/04/2026
Client	Fulton Hogan Land Development Ltd	Drawn by	JK
Reference Number	24019	Approved by	CM

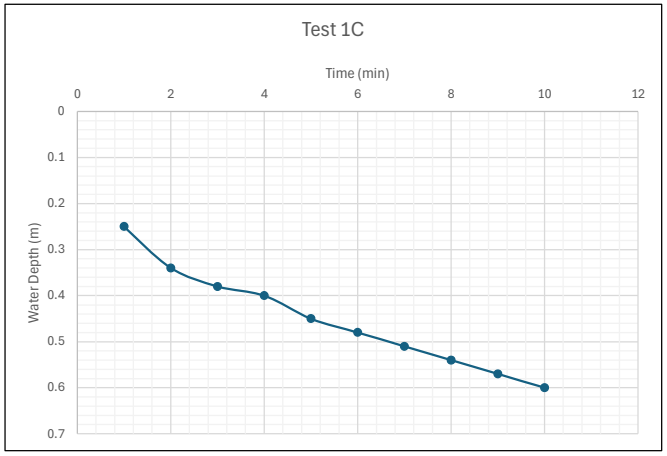
Appendix 2

Soil Permeability Calculation Worksheets

Measurements

Test 1C

Time (min)	Difference in depth (m)
0	
1	0.25
2	0.34
3	0.38
4	0.4
5	0.45
6	0.48
7	0.51
8	0.54
9	0.57
10	0.6
	empty



Calculations

Percolation Rate Calculation (Method 1):

$P = V_y/(AT \times X)$

Length pit	1.2	m
width pit	1	m
y*	0.03	m
d**	0.045	m
water vol V_y	0.036	m^3
wall area A1	0.06	m^2
wall area A2	0.072	m^2
base area AB	1.2	m^2
total area AT	1.332	m^2
Percolation rate P	0.027	m/min
Percolation rate P	27.027	mm/min
Percolation rate P	**1621.622**	**mm/hr**
Percolation rate P	**4.50E-04**	**m/s**

*y is the depth difference btw the last 2 points
**d is the distance btw the midpoint of the last 2 readings and the base of the pit
X is the time interval between the last two points in minutes

BRE Digest Method:

$$f = \frac{V_{p75-25}}{a_{p50} \times t_{p75-25}}$$

Length	1.2	m
Width	1	m
Depth	0.6	m
Area Base Abase	1.2	m^2
H eff storage depth	0.4	m
*V_{p75-25}	0.24	m^3
75% depth	0.3	m
25% depth	0.1	m
50% depth	0.2	m
**A_{p50}	2.08	m^2
***Tp75	1.5	min
****Tp25	6.5	min
T_{p75-25}	5	min
	300	s
Infiltration rate f	**3.846E-04**	**m/s**
Infiltration rate f	**1384.615**	**mm/hr**

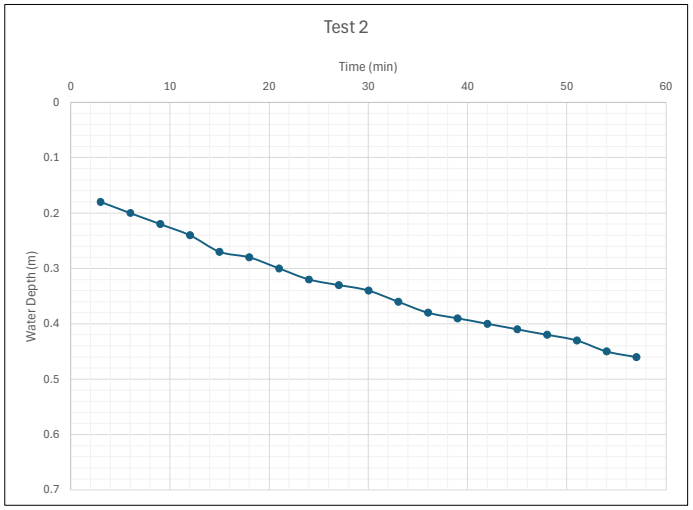
*Vol lost btw 75% and 25% of effective depth
**Mean surface area at 50% depth (incl base)
***Time at 75% depth of effective depth
****Time at 25% depth of effective depth

Measurements

Test 2

Time (min)	Difference in depth (m)
0	
3	0.18
6	0.2
9	0.22
12	0.24
15	0.27
18	0.28
21	0.3
24	0.32
27	0.33
30	0.34
33	0.36
36	0.38
39	0.39
42	0.4
45	0.41
48	0.42
51	0.43
54	0.45
57	0.46

Base of TP is 0.6m



Calculations

Percolation Rate Calculation (Method 1):

$P = V_y/(AT \times X)$

Length pit	1.2	m
width pit	1.1	m
y*	0.01	m
d**	0.145	m
water vol V_y	0.0132	m^3
wall area A1	0.022	m^2
wall area A2	0.024	m^2
base area AB	1.32	m^2
total area AT	1.366	m^2
Percolation rate P	0.003	m/min
Percolation rate P	3.221	mm/min
Percolation rate P	**193.265**	**mm/hr**
Percolation rate P	**5.37E-05**	**m/s**

*y is the depth difference btw the last 2 points
**d is the distance btw the midpoint of the last 2 readings and the base of the pit
X is the time interval between the last two points in minutes

BRE Digest Method:

$$f = \frac{V_{p75-25}}{a_{p50} \times t_{p75-25}}$$

Length	1.2	m
Width	1.1	m
Depth	0.6	m
Area Base Abase	1.32	m^2
H eff storage depth	0.45	m
*V_{p75-25}	0.297	m^3
75% depth	0.3375	m
25% depth	0.1125	m
50% depth	0.225	m
**A_{p50}	2.355	m^2
***Tp75	14	min
****Tp25	57	min
T_{p75-25}	43	min
	2580	s
Infiltration rate f	**4.888E-05**	**m/s**
Infiltration rate f	**175.974**	**mm/hr**

*Vol lost btw 75% and 25% of effective depth
**Mean surface area at 50% depth (incl base)
***Time at 75% depth of effective depth
****Time at 25% depth of effective depth

Appendix 3

Laboratory Particle Size Distribution Result (Pit Run)

Work Order ID: CTS25W1915

Central Testing Services
18 Ngapara Street, Alexandra 9340, Central Otago
P.O Box 397, Alexandra, Central Otago
Telephone: +64 3 4487644
www.centraltesting.co.nz

Material Test Report

Report No: MAT:CTS25S-01765
Issue No: 1

Client:
Cant Land Resource
Corner Main South & Halswell Junction Rd
Hornby

Christchurch 8042
NZ

Project: Parkburn Investigations

The tests reported herein (unless otherwise indicated) have been performed in accordance with the laboratory's scope of accreditation. Samples are tested as received, in natural condition, unless stated otherwise in the comments. This report may only be reproduced in full.

The results in this report relate only to the items / samples that were tested

Approved Signatory: Carl Julius
(Laboratory Technician)
IANZ Accreditation No:434
Date of Issue: 6/06/2025

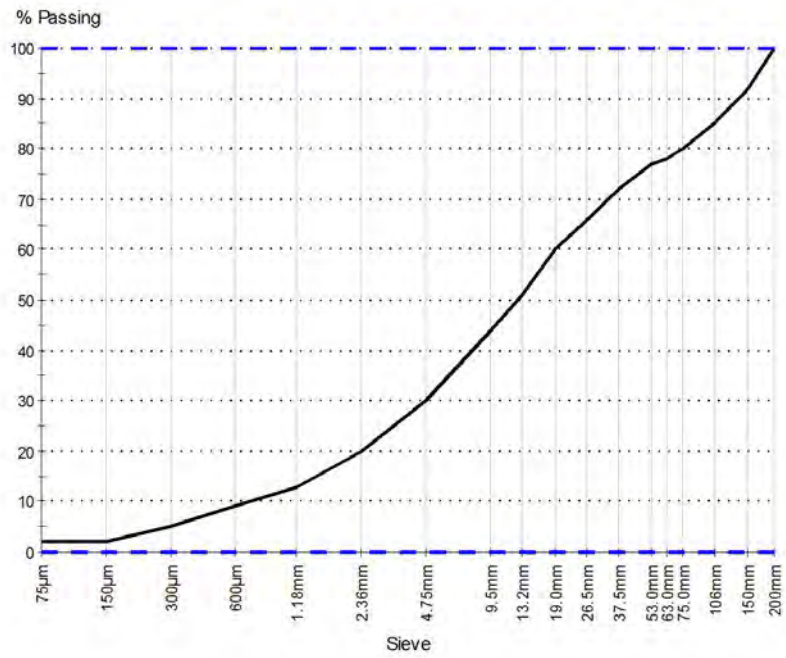
Sample Details

Sample ID: CTS25S-01765
Client Sample ID: 09674
Material: Pit Run - Cobbly GRAVEL with minor sand and trace of silt
Sample Source: Central - Parkburn Quarry
Site/Sampled From: Stockpile
Date Sampled: 26/05/2025
Specification: No Specification
Sampled By: Cam Maxwell
Sampling Method: NZS 4407:2015 2.4.6.3.2 (SP/WG/MACHINE)
Technician: Adam Rowe
Sampling Endorsed?: Yes

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: NZS 4407:2015 Test 3.8.1
Drying By: Oven
Date Tested: 30/05/2025
Tested By: Adam Rowe
Note: [a] Obtained by difference.

Sieve Size	% Passing	Limits
200mm	100	0 – 100
150mm	92	0 – 100
106mm	85	0 – 100
75.0mm	80	0 – 100
63.0mm	78	0 – 100
53.0mm	77	0 – 100
37.5mm	72	0 – 100
26.5mm	66	0 – 100
19.0mm	60	0 – 100
13.2mm	51	0 – 100
9.5mm	44	0 – 100
4.75mm	30	0 – 100
2.36mm	20	0 – 100
1.18mm	13	0 – 100
600µm	9	0 – 100
300µm	5	0 – 100
150µm	2	0 – 100
75µm	2[a]	0 – 100

Comments

Date Received: 27-May-25

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Appendix I: Draft Cove Dewatering Management Plan

1. Purpose and status

This Dewatering Management Plan (DMP) describes the preliminary methodology for managing groundwater encountered during landward (i.e. prior to connecting to the lake) excavation of the two proposed coves adjacent to Lake Dunstan/Te Wairere.

This DMP has been prepared at a preliminary design stage to demonstrate a practicable framework for dewatering and managing associated discharges. It is based on currently available geotechnical and permeability information, preliminary cove geometry and conservative assumptions regarding groundwater conditions.

The final groundwater inflow rates, pumping requirements and treatment capacity cannot presently be determined with sufficient confidence for detailed design. Accordingly, the estimates and methodologies presented in this DMP will be verified through site-specific investigations, including groundwater monitoring, saturated permeability testing and/or trial pumping.

The results of those investigations will inform an updated DMP incorporated into the final CEMP submitted to Otago Regional Council (ORC) for review and acceptance before cove excavation below groundwater level begins.

The primary objectives of the DMP are to:

- minimise the volume of groundwater requiring pumping and treatment;
- maintain safe and practicable working conditions within the cove excavations;
- minimise the generation of sediment-laden dewatering water;
- provide sufficient treatment capacity for the anticipated dewatering flow;
- prevent the discharge of potentially sediment-laden water to Lake Dunstan/Te Wairere; and
- provide monitoring and contingency measures that enable the dewatering system to respond to changing groundwater and construction conditions.

This approach is consistent with the general dewatering principles in Auckland Council's Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region (GD05), which emphasises minimising dewatering volumes, appropriately treating sediment-laden pumped water, monitoring discharges and preparing a specific dewatering plan where dewatering is required. This

management plan is also consistent with Section 6.7 (Dewatering) of the ORC Guidelines.

2. Site and groundwater conditions

The proposed works include formation of two coves extending inland from the existing Lake Dunstan/Te Wairere shoreline. The northern cove is approximately 29 m long and up to approximately 40m wide, while the southern cove is approximately 200 m long and up to approximately 30m wide (Viridis Environmental Consultants, 2026).

The site is predominantly underlain by Late Pleistocene outwash deposits. These generally comprise sandy gravels with cobbles and occasional boulders, with quarrying having exposed these materials across substantial parts of the site. Previously quarried areas also contain various fill materials, including loose pea gravel (Insight Engineering, 2026a; Geotago, 2022).

Groundwater has previously been encountered within test pits on the lower quarry floor at approximately 1.1–1.6 m below ground level. The existing geotechnical information indicates that groundwater beneath the quarry is reasonably static and hydraulically connected with Lake Dunstan/Te Wairere. The lake has a normal operating range of approximately 193.5–194.5 m AOD (Geotago, 2022; Landpro, 2026).

For the purposes of this preliminary assessment, 194.5 m AOD has therefore been adopted as the assumed maximum groundwater elevation.

Based on the current cove earthworks model, the approximate excavation volumes below 194.5 m AOD are presented in the following table.

Cove	Approx. excavation below 194.5 m AOD
Southern cove	21,900 m^3
Northern cove	30,800 m^3
Total	**52,700 m^3**

The northern cove has an approximate overall excavation footprint of 1.4 ha. The 30,800 m^3 below the assumed maximum groundwater level therefore represents an average below-groundwater excavation depth of approximately 2.2 m across this footprint, although the maximum excavation depth below groundwater may locally approach approximately 5 m.

3. Available permeability information

Insight Engineering undertook three shallow permeability tests at Parkburn Quarry in April 2026. The tests were undertaken in 0.6 m deep test pits and were intended to inform erosion and sediment control planning rather than detailed groundwater or dewatering design (Insight Engineering, 2026b).

The calculated infiltration rates were:

- Test 1: 3.85×10^{-4} m/s, equivalent to approximately 1,380 mm/hr; and
- Test 2: 4.9×10^{-5} m/s, equivalent to approximately 175 mm/hr.

Test 3 was located closer to Lake Dunstan/Te Wairere, with the test pit base estimated to be approximately 0.5–1 m above lake level. No measurable drainage occurred during the 45-minute test period.

The tested materials generally comprised sandy fine-to-coarse gravel with cobbles and trace silt. Laboratory grading of representative pit-run material describes cobbly gravel with minor sand and trace silt, with approximately 2% passing the 75 μm sieve (Insight Engineering, 2026b).

The measured infiltration rates have not been directly adopted as saturated horizontal hydraulic conductivity values. The tests were shallow, predominantly within initially unsaturated materials, were not pre-soaked, and were not undertaken as groundwater pumping tests. Insight Engineering (2026b) also identifies the limited nature of the investigation and potential for conditions to vary between investigation locations.

Nevertheless, the results provide useful site-specific information regarding the likely order of magnitude of permeability. For preliminary dewatering assessment, the following values have therefore been adopted:

Scenario	Preliminary hydraulic conductivity (K)
Lower	5×10^{-5} m/s
Representative	1×10^{-4} m/s
Upper	5×10^{-4} m/s
Conservative sensitivity case	1×10^{-3} m/s

These values are preliminary screening assumptions rather than design values and will be replaced or refined following the detailed groundwater investigations described in Section 5.

4. Preliminary dewatering assessment

A preliminary screening assessment has been undertaken using the available permeability information, cove geometry and an assumption that groundwater is hydraulically connected to Lake Dunstan/Te Wairere.

For the northern cove, which represents the larger dewatering area, indicative sustained groundwater inflows for the full excavation footprint are estimated as follows:

Assumed K	Indicative groundwater flow
5×10^{-5} m/s	approximately 3–11 L/s
1×10^{-4} m/s	approximately 6–22 L/s
5×10^{-4} m/s	approximately 26–110 L/s
1×10^{-3} m/s	approximately 52–220 L/s

These estimates are order-of-magnitude screening values only. Actual inflow will depend on saturated hydraulic conductivity, groundwater and lake levels, excavation geometry, distance from the lake, local geological variability, effectiveness of hydraulic isolation and the size of the active excavation cell.

On the information presently available, groundwater inflow in the order of approximately 20–100 L/s is considered a reasonable preliminary central range for planning purposes. Approximately 200–250 L/s is retained as a conservative sensitivity range pending field verification.

Actual operational flows may be appreciably lower because the full cove footprint will not be dewatered simultaneously. The staged-cell methodology described in Section 6 is intended specifically to reduce the active drawdown footprint and resulting pumping requirement.

The estimates in this section are not intended to establish the design capacity of the final dewatering system. That capacity will be established following the investigations described below.

5. Detailed investigation and final dewatering design

Before significant excavation below groundwater level begins, targeted groundwater investigations will be undertaken by a suitably qualified and experienced person (SQEP).

The investigation programme will include, as appropriate:

- installation of groundwater monitoring points within and around the proposed cove excavation areas;
- monitoring of groundwater and Lake Dunstan/Te Wairere levels;
- saturated permeability testing within representative materials at relevant excavation depths;
- trial pumping within or immediately adjacent to the proposed cove excavations; and
- monitoring of groundwater response during trial pumping to assess hydraulic connectivity with Lake Dunstan/Te Wairere.

Trial pumping will be particularly important because the existing shallow infiltration tests do not establish the rate at which the saturated gravel aquifer and Lake Dunstan/Te Wairere may replenish an excavation under sustained drawdown.

The investigation results will be used to:

- verify or revise the preliminary hydraulic conductivity assumptions;
- determine representative and conservative groundwater inflow rates;
- establish appropriate excavation cell dimensions;
- determine required pumping and standby capacity;
- establish required treatment capacity; and
- determine whether temporary hydraulic cut-off measures are necessary or beneficial.

An updated DMP incorporating the investigation results, supporting calculations and final dewatering design will form part of the final CEMP submitted to ORC for review before any dewatering associated with cove excavation begins.

6. Excavation staging and inflow minimisation

Only one cove will be actively excavated below groundwater level at any one time, with cove excavation to be substantially completed on the landward side of Lake Dunstan prior to "breaking through" into the wetted bed of the lake. Note that, at this stage, it is assumed that cove formation/excavation on the lake bed can occur within the water column (therefore no dewatering is expected to be required for this aspect of the works).

Each cove will also be divided into a series of smaller excavation cells. Dewatering will be limited to the active cell or cells required for the immediate construction activity rather than attempting to lower groundwater across the entire cove footprint.

This approach is consistent with the general principle in GD05 that erosion and source controls that reduce the volume requiring dewatering are preferable to relying solely on downstream sediment treatment.

The number, dimensions and sequence of excavation cells will be determined during detailed construction planning following completion of the groundwater investigations.

The excavation sequence will seek to:

- minimise the area and duration of excavation below groundwater level;
- retain undisturbed material between Lake Dunstan/Te Wairere and the active excavation for as long as practicable;
- progressively complete excavation before moving to subsequent cells;
- avoid unnecessary groundwater drawdown outside the active work area; and
- minimise the pumping and treatment capacity required at any one time.

Completed cells may be allowed to re-wet where this does not interfere with subsequent construction.

If groundwater inflow exceeds the practical capacity of the proposed pumping and treatment system, the construction methodology will be reviewed before simply increasing pumping capacity. Responses may include reducing excavation cell size, modifying excavation sequencing, installing temporary sheet piling or another hydraulic cut-off, limiting the duration or depth of drawdown, or undertaking suitable components of the excavation in the wet.

7. Dewatering collection

Groundwater will be collected using appropriately positioned sumps, wells, wellpoints, gravel collection trenches or a combination of these methods. The final collection system will be determined following the detailed groundwater investigation and confirmation of excavation staging.

Where practicable, relatively clean groundwater will be intercepted before it passes through active earthworks. Water collected directly from active excavation areas will be treated as potentially sediment-laden unless monitoring demonstrates otherwise.

Pumps will be positioned and operated to minimise disturbance of exposed soils and entrainment of fine sediment. Pump intakes will be appropriately screened and elevated above accumulated sediment where practicable.

Clean surface runoff will be diverted around the active excavation in accordance with the ESCP so that rainfall runoff from surrounding areas does not unnecessarily increase the volume requiring dewatering and treatment.

8. Dewatering treatment

Dewatering water that does not meet the applicable discharge criteria will be treated before discharge.

GD05 identifies settlement, sediment retention devices and flocculant treatment as potential management measures where pumped water does not meet the required discharge standard. It also emphasises that treatment devices receiving pumped flows need to be appropriately sized and that dewatering discharges require close monitoring.

Given the potentially significant pumping rates associated with excavation of the coves, conventional sediment retention ponds or infiltration basins are not proposed as the primary treatment or disposal method for cove dewatering. Instead, the principal treatment system is anticipated to comprise modular high-rate clarification, with chemical treatment where required.

The indicative treatment train is:

Dewatering pumps → equalisation/buffer storage → chemical dosing and flocculation → lamella clarification → water-quality monitoring → discharge

Multiple lamella clarification units will be installed and operated in parallel as necessary to provide the required treatment capacity. This modular arrangement will enable treatment capacity to be matched to the pumping rates established through field investigation and adjusted during construction where required.

The number and rated capacity of the lamella units will not be prescribed until the field investigation and trial pumping programme has established an appropriate design flow.

Chemical treatment will be confirmed through bench testing using representative dewatering water. The treatment chemical and dose will be selected based on treatment performance, actual suspended sediment characteristics, water chemistry and suitability for discharge to the receiving environment.

The treatment system will incorporate sufficient buffer/equalisation capacity to accommodate short-term fluctuations in pumping rate and treatment performance. Buffer storage is not intended to provide long-term storage of the entire dewatering flow.

9. Discharge of treated water

Subject to the relevant resource consent requirements and confirmation that applicable water-quality criteria are achieved, treated dewatering water is expected to be returned to Lake Dunstan/Te Wairere.

This is considered preferable to attempting large-scale infiltration within the site because groundwater beneath the lower quarry is understood to be hydraulically connected to the lake (Geotago, 2022; Landpro, 2026). Large-scale infiltration within highly permeable lake-margin materials could potentially recycle pumped groundwater towards the active excavation and increase the overall dewatering requirement.

The final discharge location and outlet arrangement will be confirmed during detailed design. The discharge system will:

- avoid erosion and scour of the lake bed or margins;
- provide appropriate energy dissipation;
- minimise the potential for discharged water to recirculate towards the active excavation;
- avoid unnecessary disturbance of aquatic habitat; and
- enable representative monitoring of discharge water.

Untreated sediment-laden dewatering water will not be discharged directly to Lake Dunstan/Te Wairere.

10. Water quality monitoring

The final DMP will establish discharge performance criteria consistent with the relevant resource consent conditions and final CEMP.

As a minimum, monitoring is expected to include:

- discharge flow rate;
- turbidity;
- pH; and
- visual assessment of the discharge and receiving environment.

Additional parameters will be included where warranted by the selected treatment chemicals, baseline water-quality monitoring or consent conditions.

Monitoring frequency, trigger levels and response requirements will be confirmed in the final DMP.

Where monitoring identifies that treated water does not meet the applicable discharge criteria, discharge to Lake Dunstan/Te Wairere will cease and water will be redirected to buffer storage or recirculated through the treatment system until acceptable treatment performance is restored.

11. Treatment residuals

Sediment and sludge accumulated within sumps, tanks and lamella clarification units will be removed as required to maintain treatment performance.

Clarifier sludge will be directed to an appropriately contained dewatering system, which may include geotextile dewatering bags, a bunded drying area or a proprietary sludge-management system.

Dewatered sediment may be reused within the site where it is demonstrated to be geotechnically and environmentally suitable. Material unsuitable for reuse will be disposed of at an appropriately authorised facility.

12. Monitoring and adaptive management

Groundwater conditions, pumping rates and treatment performance will be monitored throughout dewatering.

Records will include, as appropriate:

- groundwater and Lake Dunstan/Te Wairere levels;
- pumping rates and cumulative pumping volumes;
- treatment plant flow rates;
- chemical dosing rates;
- treated-water quality;
- observations of groundwater ingress and excavation conditions;
- treatment system maintenance and desludging activities; and
- incidents, exceedances and corrective actions.

Actual groundwater inflows will be compared with the values used to design the system. The treatment system and excavation methodology will be adapted where actual conditions differ materially from those predicted.

If inflow approaches available treatment capacity, consideration will first be given to reducing the active dewatering footprint or groundwater inflow through changes to cell size, sequencing or hydraulic isolation rather than relying solely on increased pumping and treatment capacity.

13. Contingency measures

Standby pumping and treatment capacity will be provided appropriate to the final design flow and consequences of equipment failure.

The final DMP will establish trigger levels and response measures for circumstances including:

- groundwater inflow approaching pumping or treatment capacity;
- unexpected rapid groundwater ingress;
- treatment plant malfunction;
- treated water exceeding discharge criteria;
- chemical dosing failure;
- significant rainfall;
- material changes in Lake Dunstan/Te Wairere level; and
- instability or erosion associated with groundwater inflow or discharge.

Responses may include reducing or temporarily stopping excavation, reducing excavation cell size, installing additional hydraulic isolation, increasing treatment capacity, recirculating water through the treatment system, adjusting chemical treatment or temporarily ceasing discharge.

Where compliant discharge cannot be maintained, excavation below groundwater level will cease until adequate dewatering and treatment capacity is restored.

14. Dewatering pit decommissioning

At the completion of dewatering, any dewatering pits or bores that have been constructed to enable cove works below the water table will be decommissioned by backfilling with clean, inert material. The fill material is to be placed and compacted so as to avoid the formation of a preferential contaminant pathway to groundwater.

15. Review and finalisation

This DMP establishes the preliminary management framework for cove dewatering. It reflects the level of design and groundwater information currently available and is not intended to represent the final construction-level dewatering design.

The preliminary assessment via the available information indicates a hydraulic conductivity range of approximately 1×10^{-4} to 5×10^{-4} m/s for planning purposes, with 1×10^{-3} m/s retained as a conservative sensitivity case. The existing permeability testing was not designed to determine saturated aquifer hydraulic

conductivity or sustained groundwater inflow to a dewatered excavation and therefore does not provide an appropriate basis, in isolation, for final system design (Insight Engineering, 2026b).

Before excavation below groundwater level begins, the preliminary assumptions and estimates in this DMP will be verified or validated through detailed groundwater investigation and dewatering assessment. The DMP will then be updated to incorporate:

- measured groundwater and Lake Dunstan/Te Wairere levels;
- site-specific saturated hydraulic conductivity;
- trial-pumping results and observed groundwater response;
- refined groundwater inflow calculations;
- final cove excavation staging and cell dimensions;
- design pumping rate and standby capacity;
- final lamella clarification capacity and number/configuration of treatment units;
- chemical-treatment selection and bench-testing results (if required);
- buffer and contingency storage requirements;
- final discharge location and outlet design;
- discharge performance criteria;
- monitoring requirements; and
- trigger and response procedures.

The updated DMP will form part of the final CEMP provided to ORC for review and acceptance before cove dewatering activities commence.

16. References

Auckland Council. 2016. Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region. Guideline Document GD2016/005 (GD05). Knowledge Auckland

Geotago Ltd. 2022. Geotechnical Assessment for Proposed Residential Development, Parkburn.

Insight Engineering. 2026a. Geotechnical and Earthworks Assessment for Proposed Residential Subdivision at Parkburn Quarry, 922 Luggate-Cromwell Road (SH6), Cromwell.

Insight Engineering. 2026b. Soil Permeability Testing, Parkburn Quarry.

Landpro Limited. 2026. Parkburn Subdivision Environmental Management Plan.

Viridis Environmental Consultants. 2026. Parkburn, Luggate-Cromwell Road: Ecological Impact Assessment.

Appendix J: Dust Management Plan

(to be provided in Final EMP)

Appendix K: Noise and Vibration Management Plan

(to be provided in Final EMP)

Appendix L: Draft Lizard Management Plan

VIRIDIS
Environmental Consultants

Parkburn, Luggate-Cromwell Road

Draft Lizard Management Plan

Prepared for: Fulton Hogan Land Development Limited

July 2026



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Cover photo: Lizard habitat within the Parkburn site, February 2026

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1 INTRODUCTION

1.1 Purpose of this Lizard Management Plan

This Lizard Management Plan (LMP) has been prepared to identify and manage the actual and potential adverse effects of the proposed Parkburn residential subdivision development on indigenous lizards and lizard habitat at 922 Luggate-Cromwell Road, Cromwell.

The LMP outlines procedures and management measures relating to:

- pre-construction lizard salvage;
- vegetation clearance supervision;
- lizard capture, handling, and relocation;
- release-site establishment and habitat enhancement;
- pest animal management;
- post-release monitoring; and
- completion reporting.

The overall objective of this LMP, and the purpose of the activity with regard to Schedule 7 of the Fast Track Approvals Act 2024 (FTAA), is to avoid, minimise, and mitigate adverse effects on indigenous lizards and achieve no net loss of lizard populations associated with the development. This will be achieved by salvaging and relocating any individuals present within suitable habitat before and during vegetation clearance, earthworks and associated habitat removal.

This draft LMP accompanies the FTAA application and associated Wildlife Act Authorisation (WAA) application and will be finalised following confirmation of construction methodologies, detailed design, and consultation with the Department of Conservation (DoC).

1.2 Project Background

Fulton Hogan Land Development (FHLD) Limited has applied for resource consent through the Fast Track Approvals Act (2024) (FTAA) to develop a residential subdivision on the property at 922 Luggate-Cromwell Road (State Highway 6), Cromwell.

The proposed development includes:

- earthworks;
- vegetation clearance;
- installation of stormwater infrastructure;
- quarry rehabilitation; and
- associated residential development works.

The site has been heavily modified through historical agricultural use and more recent quarrying activities. However, areas of indigenous lizard habitat remain within portions of the site, particularly within areas of rank grassland, woody debris, scrub vegetation, and the Park Burn riparian corridor. As a result, there is potential for indigenous lizards to be adversely affected by vegetation clearance and habitat disturbance associated with the proposed works.

This LMP should be read in conjunction with the Parkburn Ecological Impact Assessment Report ('EcIA')[1], which assesses the ecological values of the site and the potential effects of the proposed works.

[1] Viridis. 2026. Parkburn, Luggate-Cromwell Road, Ecological Impact Assessment. Prepared for Fulton Hogan Land Development Limited.

2 SITE CONTEXT, ECOLOGICAL VALUES, AND POTENTIAL EFFECTS

2.1 Site Description

The site is located in the Pisa Ecological District (ED) of the Central Otago Region. The Pisa ED is characterised by mid to high elevation ranges and flats in some locations. The climate is generally dry, with cold winters and some small snowbanks that persist through summer. Tussocklands would have predominated historically, however now much of the district is modified by pastoral farming. Very small remnants of native forest remain. Fauna habitat has been degraded and reduced over time as agricultural and urban development expanded.

The site represents a highly modified area of the ecological district. While not currently urbanised, the site contains an active gravel quarry and has been heavily modified over the past 40 years. Prior to the quarry being established, the site was used for agricultural purposes. The neighbouring property to the north is formed by another active gravel quarry, while to the south is an existing residential development of Pisa Moorings. The western boundary is Luggate-Cromwell Road (SH6) with horticultural land beyond. The hydroelectric Lake Dunstan is located on the site's eastern boundary. Further afield is the township of Cromwell.

Historically (pre-human) the site likely comprised scrub and/or tussockland. The wider area has been farmed since the 1860s and therefore it is likely it has been devoid of any significant native vegetation for more than 150 years. Lake Dunstan, on the site's eastern boundary, was first filled between 1992 and 1993. Prior to this, the Clutha River was located approximately 500 m beyond the site's boundary.

Currently the site is occupied by an operational gravel quarry, with various buildings associated with the quarry and the manufacture of products such as paving blocks.

The location of the site is shown in Figure 1.

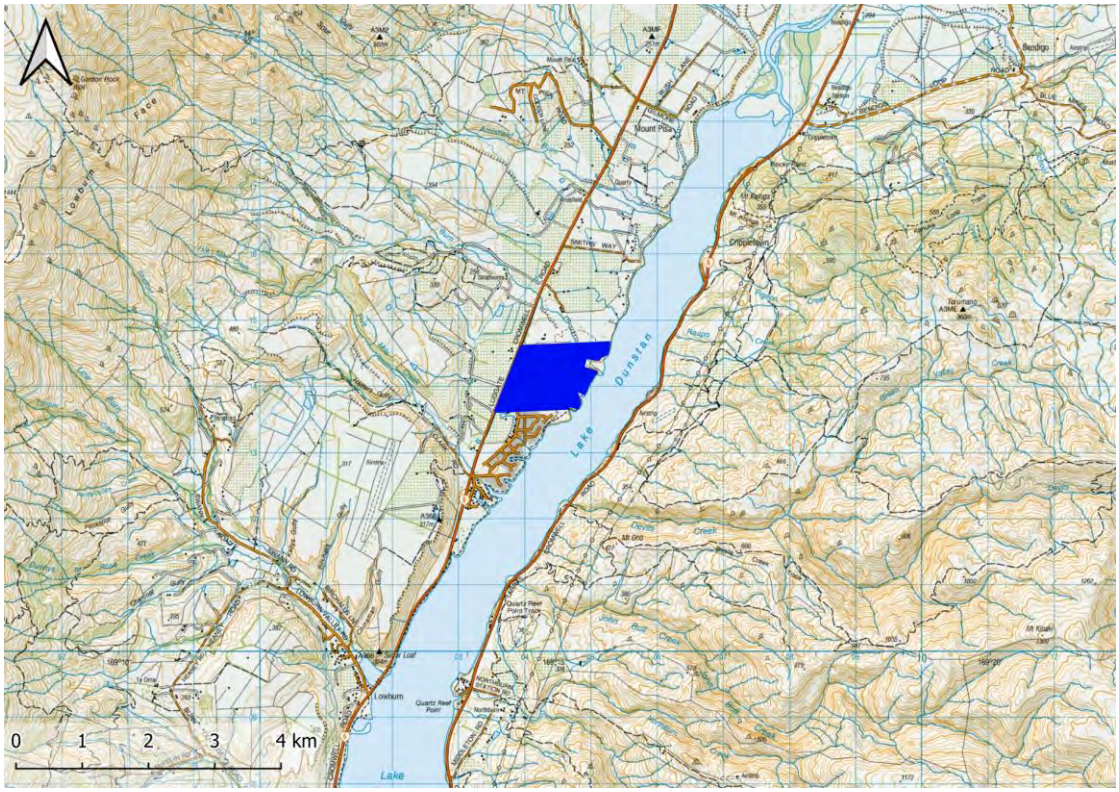


Figure 1. Site location as indicated by blue polygon (map source: LINZ NZ Topo 50).

2.2 Species Potentially Present

Viridis (2026) contains the results of a desktop review of lizard data, a site assessment to assess the presence of suitable habitat on the site, and results of a survey completed by Lizard Expert NZ within the site. The results of the findings are summarised below.

A review of Department of Conservation's (DoC) Herpetofauna database (accessed November 2024) for records within 10 km of the site identified nine lizard species. Two species of lizard have been recorded – McCann's skink (*Oligosoma maccanni*; Not Threatened) and Kawarau gecko (*Woodworthia* "Cromwell"; At Risk – Declining (nationally) and Regionally Declining (regionally)).

Lizard habitat within the site was mostly limited to areas of moderate and long grass that had not been subject to quarrying (Figure 3). Additionally, habitat was also present within the Park Burn riparian area between the site and the lake margins. Some areas of debris were present within the site, including dead trees and wood, which provided refugia and basking habitat for skinks. Habitat typically associated with Kawarau gecko was not identified within the site, and geckos are therefore considered highly unlikely to be present.. No lizards are expected to be present in the actively quarried area, and as such, values associated with lizard habitat are not attributed to these areas.

A lizard survey was undertaken in December 2025. One hundred baited Gee's minnow traps were distributed throughout the site (Figure 3), and this was complemented by manual hand searches in other suitable habitats. The areas were focused around areas where lizard habitat values were present, i.e. not within the actively quarried area. A total of 80 McCann's skink and one tussock skink (*Oligosoma chionochloescens*; At Risk – Declining; Regionally Declining) were captured in traps and by hand searches during the survey. An additional 38 separate observations of skink presence (guano, skins) were also noted. These observations were attributed to McCann's skink due to their locations and the habitat they were found in. An additional two observations were attributed to tussock skink, however these observations were outside of the site on the lake margin.

2.3 Lizard Habitat

McCann's skink are likely to be present throughout the site where habitat is suitable, i.e. not within the actively quarried areas. It is possible tussock skink may be present, predominantly in the Park Burn riparian corridor, although the survey did not detect any tussock skink in this area. The site contained areas of long grass that provides low-moderate skink habitat. These areas were within a wider quarry area and are subject to period mowing to prevent grass getting too long. Where grass was regularly cut or mown, habitat values were considered low. Where grass was in close proximity to trees or shrubs, it was considered to be low-moderate. Where fallen debris was present amongst grass, lizard habitat was considered to be moderate.

Examples of these habitats present on the site are shown in Figure 2.



Figure 2. Examples of potential lizard habitat within the proposed works area scrubby vegetation and woody debris.

2.4 Lizard Densities

Native lizard density estimates vary by habitat type and quality, and factors such as predation, historical site disturbance and population dynamics. It is not possible to reliably estimate population sizes and densities without detailed mark–recapture data. Given the very common nature of McCann's skink, the heavily dominant species within the site, mark and recapture was not considered necessary.

Regardless, densities of lizards expected to be present within the works footprint have been estimated based on existing information and based on the survey effort (number of traps, number of survey days) undertaken as part of the baseline survey of the site. Density estimates are available for McCann's skink (Wilson et al. 2017), and also for southern grass skink which has been used as a proxy for tussock skink given their very similar habitats and recent classification as two separate species. In high quality habitat, southern grass skink can reach up to ~9,200 skinks per ha while McCann's skink can reach up to ~2,250 skinks per ha.

The works area comprises approximately 1.7 ha of moderate value habitat (long grass with basking debris), approximately 11 ha of low-moderate (maintained grass in proximity to trees/shrubs) and 33 ha of low quality habitat (periodically mown grass).

Given the low to moderate habitat quality with no pest mammal management, and the results of the preliminary survey, a rough estimate of 25 skinks per ha could be expected across the site. This would equate to approximately 1,150 McCann's skinks in the project footprint.

Tussock skink habitat is largely unimpacted. A conservative estimate of approximately 0.6 ha of tussocks skink habitat is within the earthworks footprint. Given the low to moderate habitat quality with no pest mammal management, and the limited detection during the survey, a rough estimate of 10 skinks per ha could be expected. This would equate to <10 tussock skink within the project footprint potentially affected by the works.

2.5 Proposed Site Works

The majority of the vegetation within the site is proposed to be removed. However, the bulk of the site comprises managed grass or active quarry. Lizard habitat is concentrated in long grass around trees, shrubs and in proximity to debris forming basking habitat. Figure 3 illustrates areas where lizards were detected during a targeted survey of the site.

2.6 Description of Impacted Habitat

The ecological values of the habitat on the site are assessed and described in Viridis (2026). The vegetation on the site affected by the proposed clearance is described as:

- Long grass around trees and shrublands.
- Woody debris forming basking habitat.
- Scrubby vegetation within the Park Burn corridor and around the edge of Lake Dunstan.

2.7 Potential Effects on Lizards

If indigenous lizards are present within the areas of vegetation clearance, potential adverse effects on lizards may include:

Direct effects:

- Mortality during vegetation clearance or habitat disturbance
- Injury during physical clearance works

Indirect effects:

- Loss of habitat
- Habitat fragmentation
- Temporary noise disturbance

Managing direct effects on lizards requires mitigation through a salvage and relocation programme. The riparian revegetation planting proposed as part of the development will help to mitigate for the loss of indigenous lizard habitat.

Avoidance of lizard habitat is not possible. However, given the ongoing quarrying activities occurring on the site, the values of the habitat at the time construction of this project commences are likely to be lower than they are currently. The impact on lizards is therefore proposed to be minimised through salvage and relocation of lizards that remain within the site when construction commences. The contents of this plan set out methods for minimisation.

3 HERPETOFAUNA MANAGEMENT

3.1 Objectives

The objectives of the herpetofauna management measures proposed are to minimise potential adverse effects on native lizards within the construction footprint by way of capturing and relocating any native lizards prior to and during vegetation removal, and providing habitat enhancement and pest control, where appropriate. Further, the proposed herpetofauna management aims to achieve the following:

- The population of each species of native lizard present on the site where works are to occur shall be maintained or enhanced on site; and
- The habitat(s) that lizards are transferred to on the site will support viable native lizard populations for all species present pre-development.

These objectives will be achieved by:

a. Using current best practice to capture native lizards from vegetation and other potential habitats in the construction footprint prior to and during vegetation clearance, and relocate any captured individuals to safe and suitable habitats (avoid and minimise mortality of wildlife protected by the Wildlife Act);

b. Setting out standard surveying and monitoring protocols that are to be followed, using the DoC Natural Heritage Management System's Herpetofauna Inventory & Monitoring Toolbox (DoC, undated) and/or using new advances in tools and techniques not yet incorporated into the toolbox;

c. Meeting requirements of the Wildlife Act and Resource Management Act.

Section 3 of the LMP addresses the following:

- Lizard capture, vegetation clearance supervision and relocation methodologies;
- A summary of the recommended on site release site;
- Post works management and monitoring (where required).

3.2 Statutory Context

Herpetofauna (reptiles and amphibians) comprise a significant component of New Zealand's terrestrial fauna. There are currently 147 native herpetofauna taxa recognised in New Zealand (Hitchmough et al., 2021; Burns et al., 2024), 88% of which are considered 'Threatened' or 'At-Risk'. All indigenous reptiles and amphibians are legally protected under the Wildlife Act 1953, and vegetation and landscape features that provide significant habitat for native herpetofauna are protected by the Resource Management Act 1991.

Statutory obligations require management of resident lizard populations where they or their habitats are threatened by disturbance or land development. This draft LMP is a site-specific plan prepared to avoid or minimise adverse construction effects and to ensure that all necessary measures for successful relocation of lizards are identified and implemented to protect and/or enhance their habitats.

Capture, handling and relocation of indigenous lizards may only be undertaken under a valid Wildlife Act Authorisation (WAA) issued by DoC.

3.3 Project Herpetologist and Methodology Finalisation

A suitably qualified herpetologist or ecologist ('project herpetologist') is required to implement this LMP, and a WAA to capture and relocate indigenous lizards is required.

Prior to undertaking lizard relocation work, the project herpetologist will review the methodologies outlined within this LMP and may amend or refine the methodologies where necessary to respond to site conditions, habitat changes, weather conditions, construction staging, or updated ecological information available at the time works commence.

The project herpetologist will have authority to modify salvage methodologies, trapping effort, search methodologies, release procedures, and timing of activities where necessary to improve salvage outcomes, minimise adverse effects on indigenous lizards, or address health and safety considerations, provided the overall intent of this LMP and any conditions of the WAA continue to be met.

Any material amendments to the methodologies outlined in this LMP will be documented by the project herpetologist and communicated to the relevant contractors and regulatory authorities where required.

3.4 Lizard Search and Capture Methodology

3.4.1 Timing of activities

Revegetation activities associated with the release site should be completed prior to commencing lizard salvage activities. Pest control should be in place within the release site prior to commencing lizard salvage activities.

Vegetation clearance should occur between October and April (inclusive). Lizard salvage activities are confined to warmer months when lizards are the most active and likely to be detected if present.

All lizard management activities are required to be undertaken during fine, calm, and dry weather. If weather is marginal, the project herpetologist will have the ultimate say on whether management activities can occur on that day.

Trapping and day searches are to be undertaken in the fortnight leading up to vegetation removal, as well as destructive searches immediately prior to and during vegetation clearance. Seven days of lizard trapping, hand searching and destructive searches of habitat will be completed in the two weeks leading up to vegetation removal. If weather conditions are unsuitable (e.g. too cold, raining) salvage will continue until seven days of salvage have been completed.

3.4.2 Trapping and habitat searches

Salvage shall occur in all areas of moderate and low-moderate value (red and orange areas) lizard habitat within the earthworks footprint (Figure 4). Salvage in low value areas will occur at the discretion of the project herpetologist depending on habitat values at the time. It is understood quarrying activities are still ongoing and therefore areas of suitable habitat at the time of works commencing are likely to be different compared to what was present during investigations for the EcIA. Areas of salvage will be confirmed by the project herpetologist prior to works commencing.

A minimum seven-day trapping period using a combination of artificial cover objects (ACOs), baited pitfall traps and/or baited funnel traps (Figure 5) will be undertaken prior to vegetation removal at a density deemed suitable by the project herpetologist. Additional trapping days may be required depending on numbers of lizards captured. Additional days will be undertaken at the discretion of the project herpetologist. Key points for this trapping are:

- All traps shall be embedded in and furnished with vegetation to protect any captured lizards from heat and exposure during confinement.
- ACOs and pitfall traps shall be installed at least four weeks prior to the commencement of trapping to allow them to 'bed in' to the environment.
- Each trap will be baited with fruit (e.g. canned pear).
- Traps are to be placed in shaded areas (as far as practicable) away from potential inundation with water and checked once per day while active to limit adverse effects on lizards (stress, desiccation, drowning, etc.).
- When not in use, all pitfall traps shall be deactivated (sealed closed or furnished to the upper rim so that lizards may escape).
- Captured lizards will be held temporarily (up to two hours) to allow traps to be cleared either in their entirety or in sections. Lizards will be stored as described in 3.4.4 below.
- All native lizards shall be released at the designated release sites following capture.

During trap checks, the project herpetologist shall hand search all vegetation, logs, rocks and debris to capture lizards and identify important areas that should be targeted for destructive searching.

a)



b)



Figure 5. a) a funnel trap, b) an ACO.

3.4.3 Destructive habitat searches

After trapping and active searches are complete, destructive habitat searches will be carried out in conjunction with the vegetation clearance or works contractor. This will involve systematic manual searches of suitable habitat (e.g. rank grass) and destruction of habitat where practicable. Leaf litter, ground cover vegetation, and small debris may be hand-raked where practicable, and larger debris overturned to search for refuging lizards.

Where vegetation growth means an area cannot practically be searched by hand, machine-assisted searches will be undertaken. This involves the project herpetologist working alongside an excavator operator as the top layer of vegetation is scraped away to reveal bare soil underneath and expose concealed lizards. The excavation methodology and bucket type used during machine-assisted searches will be determined by the project herpetologist and contractor based on site conditions and the need to effectively expose concealed lizards while minimising the risk of injury..

Machine-assisted searches will follow until all habitat for lizards have been removed and there is no suitable habitat for native lizards remaining within the affected area, as assessed by the project herpetologist.

At the conclusion of the trapping, machine-assisted searches and vegetation clearance, the suitably qualified ecologist would undertake a final site walk over to detect any remaining lizards.

3.4.4 Lizard handling and containment

All lizards will be handled as specified by the methodologies within the New Zealand Lizard Conservation Toolkit (Anderson et al., 2012).

Native lizards will only be captured and handled by or under the supervision of the DoC-authorised, suitably qualified ecologist. Hands should be sterilised before and after handling lizards, along with all field equipment that indigenous lizards may come into contact with.

Lizards will be held individually in cloth bags in a secure, vented container or in temporary containment box(es) filled with vegetation matter and leaf litter and misted with water out of the sun. Lizards will be held temporarily for the period of the active searches or trap inspections and then transported to the release site as soon as possible.

It is not anticipated that lizard taxa with conservation statuses higher than 'At Risk' would be encountered on-site. However, if 'Threatened' lizard species were encountered, the individual(s) would be captured and temporarily contained, and the local DoC office contacted for further instruction.

3.4.5 Inadvertent lizard injury or death

The following steps will be implemented should any injured or dead indigenous lizards be found during the vegetation clearance activities:

- The project herpetologist will notify DoC as soon as possible (within 24 hours);
- Any lizard death of 'Threatened', 'At Risk' or 'Data Deficient' species shall be sent to Massey University Wildlife post-mortem service for necropsy. The body should be chilled if it can be delivered within 24 hours or frozen if delivery will take longer than 24 hours;
- Appropriate measures shall be undertaken to minimise further lizard deaths;
- Injured lizards found during salvage will be taken to a suitably qualified vet as soon as possible for assessment and treatment. Injured lizards will be kept in an appropriate portable enclosure (i.e., a clean, well-ventilated (plastic container) under the direction of the project herpetologist to ensure the lizard is handled appropriately until it can be treated;
- Lizards assessed by the vet or alternative specialist as uninjured or otherwise in suitable condition for release would be transported to the relocation site in the portable enclosure and released; and

Euthanasia of an injured lizard is only to be undertaken under the direction of DoC.

3.5 Release Site

3.5.1 Selection of release site

Factors that should be considered when selecting a site to release salvaged indigenous lizards include ecological appropriateness, long-term security, habitat suitability, and protection from predators and future human disturbance (DoC Lizard Technical Advisory Group, 2019). Key considerations include, but are not limited to, the following:

- It is important that the release site is an appropriate distance from the project footprint to prevent the lizards from re-entering the works area. However, the release site should be located as close as possible to the salvage site to ensure resemblance of microhabitats and environmental conditions.
- The habitat within the release site should be representative to or of higher ecological value than the salvage site.
- Areas with long-term protection should be favoured, such as reserves managed by DoC or Council, vegetation covenants or areas protected by regional and local council overlays.
- Potential existing species composition and density at the release site should be considered as far as practicable to limit potential adverse effects of intra- and inter-species competition at the release site.

3.5.2 Proposed release site

The proposed release site is illustrated in Figure 6. The site has been selected as it meets the key criteria for a suitable lizard release area. The location is sufficiently separated from the works area to minimise, as far as practicable, salvaged lizards from re-entering the construction footprint, while remaining close

enough to provide comparable microhabitats and environmental conditions. Separation will be further supported by a lizard fence being installed around the release site which will be left in place for as long as works are being undertaken. The fence will consist of silt fencing, partially buried in the ground, held in place by waratahs and wire. The fencing will be inspected weekly for the duration the fence is in place for, and any holes repaired as soon as identified. Fencing will only be removed once all works on site have been completed.

The habitat within the release site is currently of equal value to the salvage site. It is in an area of the site that has not been quarried and will not be subject to quarrying works between now and when construction of the subdivision commences. It has remained undeveloped for at least 20 years, and contains a small number of shrubs and trees providing low levels of refugia. The area will be enhanced through removal of weeds, revegetation with appropriate native species, installation of additional basking habitat, and pest control.

The release location will be protected in perpetuity via consent notices or covenants preventing additional development and requiring vegetation to be maintained and pest control.

Release site suitability is summarised in Table 1.

Table 1. Summary of release site suitability.

Component	Assessment
Suitability of existing habitat	The release site contains habitat of similar quality and value to the rest of the site. It will be enhanced, protected and subject to predator control further increasing its suitability. These actions will be in place before lizards are released to it.
Proximity of the site from the salvage	The release site is immediately adjacent to the development site, within the same property.
Long-term protection of the site	The release site will be protected via a consent notice or covenant.
Accessibility for release	The site is readily accessible for lizard release, pest control, and monitoring.
Size of the release site and its connectivity to other habitat	The size of the release site has been calculated based on a conservative estimate of the number of lizards to be salvaged and expected carrying capacities for enhanced, protected and pest managed habitat (i.e. the release site). Approximately 1,150 skinks are expected. The release site was sized to accommodate 1 skink per square metre. The release site is 4,560 m² providing significant redundancy.
Existing lizard populations	McCann's skink are known to be present in the release site in low numbers. Given the proposed habitat enhancements, pest control and larger than necessary area, the relocated lizards will have no measurable influence on existing lizard populations (e.g., overcrowding).
Habitat enhancement opportunities	The release site will be subject to revegetation and habitat enhancement and pest control.
Existing predator control or opportunities to enhance predator control	Predator control, planting and habitat enhancements will be established in the release site prior to lizards being released.

3.5.3 Habitat enhancement of release site

Introducing new individuals into an already occupied environment could lead to competition and/or resource availability issues. Displaced lizards have a lower likelihood of survival where the carrying capacity of adjacent habitats is stressed through increased competition for fewer resources. Further, displaced animals have a higher probability of risk of predation and a rapid increase in lizard numbers in a given area is likely to result in a corresponding increase in predators.

Revegetation of the release location will be undertaken as part of the development of the site. Beyond the revegetation, specific lizard centric planting will occur in the release site and this will be completed prior to lizard salvage commencing. Silver tussock (*Poa cita*), creeping pohuehue (*Muehlenbeckia axillaris*), scrub pohuehue (*Muehlenbeckia astonii*) and mingimingi (*Coprosma propinqua*) should be planted in patches around the site to create a mosaic of lizard habitat (e.g. refugia and foraging).

Creeping pohuehue and silver tussock should be sized at PB3, while the other species should be sized at PB5. Larger plant sizes reduces the time needed for plants to establish and provide effective habitat.

Plants should be maintained until 80% ground/canopy coverage is achieved. Monitoring will be undertaken as part of general landscape planting monitoring. If plants have died and left gaps of 1 m^2 or larger, infill planting should be undertaken during the first growing season following gap identification. Dead plants should be replaced with individuals of the same species. Weed maintenance should preferentially occur by hand. Targeted spraying should only occur for significant infestations, however providing weed maintenance occurs regularly (every three months) significant infestations should not establish. The use of weed whackers or similar should be avoided.

The planting will be complemented by installation of eco piles. Eco piles are created by piling woody debris and rocks together to form complex three dimensional structures. Eco piles are used by lizards for cover, basking and foraging. The branches of exotic tree species removed during works on the wider site should be split into small sections and retained for use as lizard enhancement. Willows should not be used due to their ability to propagate from branches, unless the trees are already dead prior to clearance. A total of 40 to 50 eco piles should be located within the area at roughly equidistant separation.

3.6 Pest Control

Predator control will be undertaken in the release site before lizards are released, and for five years post release to reduce predation pressure while lizards establish within the release site. FHLD or suitably qualified individuals action on FHLD's behalf, will carry out the pest control.

Trapping will commence at least two months prior to planned release of lizards. Earlier commencement is acceptable and may be timed with lizard habitat enhancement planting. Control will be conducted over a four week period with traps baited only in week one, then actively set (with baits) in weeks two to four. At the end of week four, traps should be left *in situ*, but all baits removed.

The sections below set out recommended methods and spacing for pest control. While cats represent a significant threat to lizards, the proximity of the site to current and proposed residential areas means cats present are highly likely to be domestic.

3.6.1 Rats and mice

Four bait stations per hectare is recommended for sufficient control of rats while higher densities are generally needed for mice. For the release site, two bait stations will be installed.

Lockable (e.g., Philproof) or run through bait stations will be used where possible, these will be spaced 50 m apart in a location that are easily accessible (Figure 7). As plants establish, bait station locations should be revised as appropriate and should be placed near any trees that produce large volumes of fruits.

Philproof stations have a pin fixture which bait blocks slot onto, to prevent rats from taking the bait and storing it rather than eating it. DoubleTap (diphacinone and cholecalciferol) bait is recommended for use in these stations as it is effective for rats, mice, and for possums.

3.6.2 Mustelids and hedgehogs

One trap is recommended for every 20 hectares of land for mustelid control (i.e., stoats, weasels). DOC 200 traps inside wooden tunnels are recommended (Figure 7). Due to the size of the release area, only one trap is recommended for this site.

DOC 200s will also catch rodents and small hedgehogs. Alternatively, a GoodNature A24 self-resetting trap may be used. Ensure the entrance and inside of the wooden tunnel are kept free of debris and cobwebs so it looks like other animals have used the tunnel. The tunnel should be embedded so the base is level with the ground surface.

Placing the trap under existing tree canopy is typically recommended wherever possible. However, vegetation on the site is currently limited and therefore unlikely to provide sufficient canopy cover. Traps should be placed on edges of features (e.g. close to the lizard fence) as these provide pathways mustelids are likely to utilise. Placing the trap near a possum trap may attract mustelids when a possum is caught.

DOC 200s require regular maintenance checks and servicing to ensure the trap is firing well.

It is recommended traps are baited with fresh rabbit meat or eggs. Alternatively, salted or freeze-dried rabbit, or egg may be used, however these may be less effective.

3.6.3 Possums

One trap per hectare is generally recommended for sufficient control of possums (Figure 7) and therefore one trap will be installed within the release site.

Flipping Timmy traps or Trapinator traps will be used for simple and humane control of possums. Traps should be installed at least 1.5 m off the ground and attached firmly to a wooden surface (e.g., a wooden post) so they remain sturdy when sprung.

The traps will be baited with a food source that is not common in the area, such as a piece of freshly cut apple sprinkled with cinnamon in a Flipping Timmy trap or peanut butter in a Trapinator. Other possum lures may include citrus peel, carrots, or vegemite. Regularly alternating bait types may increase success rates as possums may learn to avoid certain lures over time. Due to the proximity to residential areas, the use of meats, fish or pet food as bait will be avoided to minimise the risk of non-target capture.

3.6.4 Lagomorphs

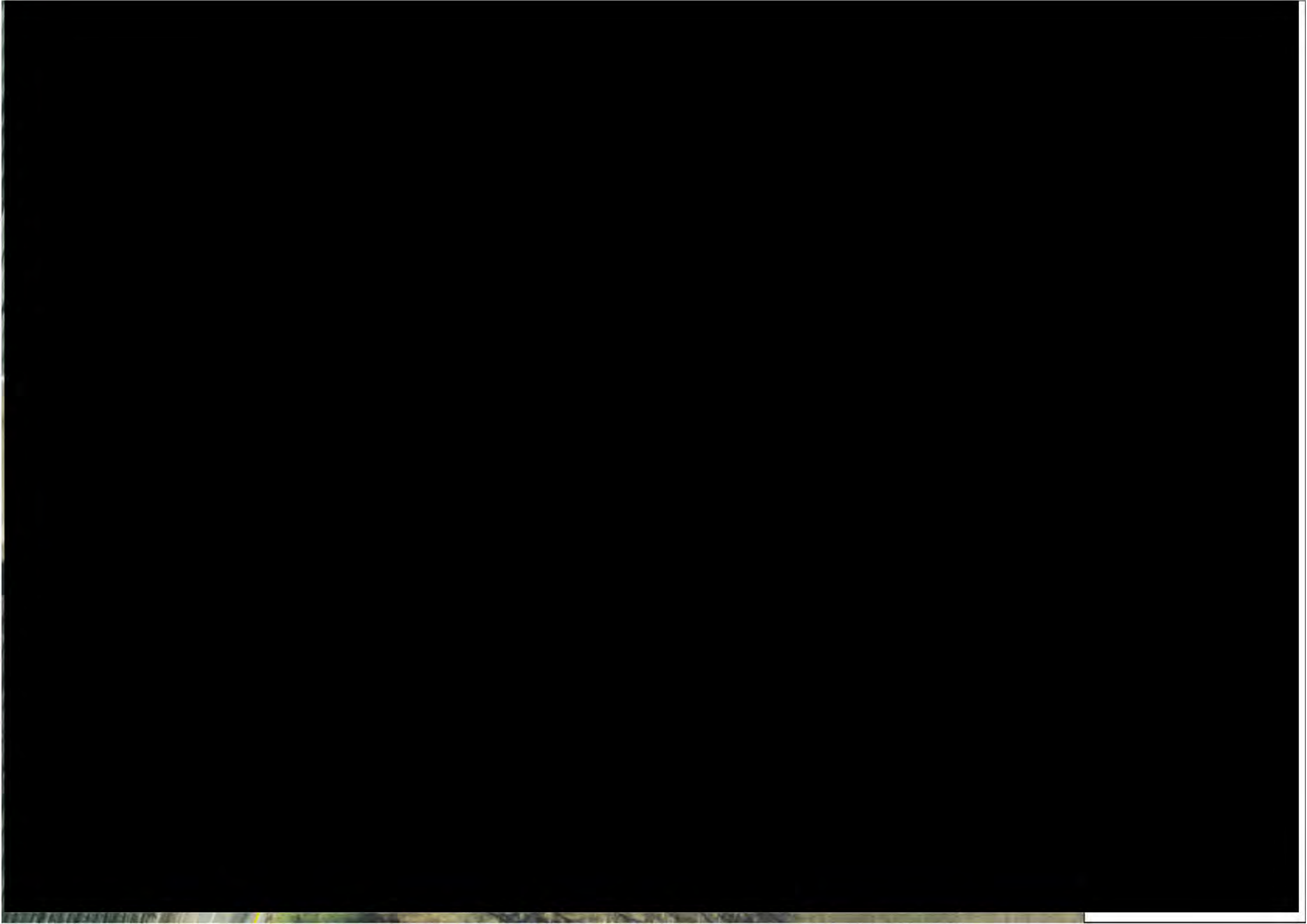
One Philproof bait station will be installed within the relocation area, along a fenceline. Pindone pellets will be used within the bait station as this type of poison bait does not require pre-feeding. Stations will be baited with Pindone for two weeks before being emptied and rebaited for another two weeks. Lagomorph control should occur two months before commencement of enhancement planting to ensure the population is low and will not damage newly planted native vegetation.

3.6.5 Pest control summary

The table below summarises the recommended methods and spacing for pest control.

Table 2. Recommended pest control methods for the lizard release site.

Pest	Method	Density	Bait / Lure	Maintenance / Notes
Rats and mice	Philproof or run-through bait stations	Two bait stations within the release site, spaced approximately 50 m apart	DoubleTap bait blocks (diphacinone and cholecalciferol)	Traps to commence at least two months prior to release. Bait stations to remain in situ and be re-baited as required. Locations may be adjusted as vegetation establishes.
Mustelids and hedgehogs	DOC 200 trap in wooden tunnel or GoodNature A24 self-resetting trap	One trap per 20 ha (one trap proposed for the site)	Fresh rabbit meat or eggs preferred; salted/freeze-dried alternatives may be used	Tunnel entrances to remain clear of debris and cobwebs. Trap to be checked and serviced regularly to ensure effective operation.
Possums	Flipping Timmy or Trapinator traps	Approximately one trap per hectare (one trap proposed within the release site)	Apple with cinnamon, peanut butter, citrus peel, carrot, vegemite, or alternative possum lures	Bait types should be rotated periodically to maintain effectiveness. Meat- or fish-based baits should be avoided due to proximity to residential areas.
Lagomorphs	Philproof bait station	One bait station within the release area, positioned along a fence line	Pindone pellets	Bait stations to be baited for two weeks, rebaited, and maintained for a further two weeks. Control to occur prior to enhancement planting.



3.7 Post Release Monitoring

Post release monitoring of the lizard population in the release site is recommended if a substantial number of lizards (>100 Mcann's skink or any other species) are salvaged from the works area. Monitoring is necessary to determine the success of the salvage and enhancement works at the release site. Monitoring will be carried out during the first season post salvage. If multiple salvages occur across seasons, the same triggers will apply, i.e. if two separate seasons salvage more than 100 lizards, monitoring will be required following both salvage seasons. The monitoring will be commissioned by FHLD Limited, and completed by a suitably qualified herpetologist/s.

The monitoring of translocated lizards to measure survivorship and population establishment is difficult without physically marking the lizards as McCann's skink are very difficult to identify to an individual level as their markings are not distinctive enough between individuals. Methods such as toe clipping are effective, but are not widely used due to ethics. Post release monitoring will therefore be focused on determining if population/s of lizards are persisting in the release site/s following salvage and release.

Standard survey techniques (i.e ACOs, baited pitfalls, baited gee's minnow traps) will be employed at the release site. The number and location of traps will be determined at the time depending on the number of lizards salvaged. Traps will be checked every day for one week during appropriate weather between November and February when lizards are at their most active. All lizards captured will be measured (snout-vent, tail-vent length), sexed, photographed, and marked with an ID number using a non-toxic marker. Survey results may be used to provide an indication of occupancy and persistence within the release site.. These results will provide an indication of how lizards are persisting in the release site/s.

The herpetologist undertaking the post-release survey may recommend additional monitoring if survey results do not indicate a healthy population. Reporting of results of the post release monitoring will specify this. The post release monitoring report, along with recommendations, will be provided to DoC. Additional habitat enhancement, pest control, or other measures may be recommended at the discretion of the project herpetologist.

3.8 Completion Reporting

A completion report would be prepared by the project herpetologist and submitted to DoC/Queenstown Lakes District Council/Otago Regional Council within **one month** of the completion of all vegetation removal. The report should detail the number of lizards captured, the locations they were captured from and the release site/s. The report would also detail whether any post-release monitoring (and timing) is recommended based on the number of lizards salvaged. An Amphibian/Reptile Distribution Scheme (ARDS) Card will be sent to the Council and DoC.

3.9 Contingency measures

Management of lizards for any project comes with some level of risk and uncertainty. While this document is intended to be a 'live' document, and subject to updates if/when necessary, Table 3 below sets out the most likely risks and uncertainties associated with management options, and includes measures to minimise or address these risks.

Table 3. Proposed contingency measures for lizard management.

Risk	Details	Likelihood	Management	Residual risk
Additional lizard species encountered	Additional species other than those listed in this LMP	Very low	Stop works, notify DOC for further instructions. Follow incidental discovery protocol.	Very low
Unsuitable weather conditions for salvage	Weather during salvage needs to be suitable for lizard activity, i.e. not cold or raining	Low	The lizard salvage season generally extends from October to April. Seven working days of salvage are still required as per sections 3.4.1 and 3.4.2. Project planning will ensure sufficient time is available prior to vegetation clearance to meet objectives if adverse weather occurs.	Very low
Relocation site failure	Failure of revegetation plantings	Very low	Planting and enhancement of the release site will be undertaken prior to lizard works commencing. If vegetation not established appropriately, lizard salvage cannot commence until alternative release site confirmed or revegetation plantings established.	Very low
Pest control failure	Failure of pest control measures to reduce/manage pest abundance	Low	Revisit pest control measures, extra pulses of pest control. Provide additional habitat features, e.g. log/rock piles.	Very low
More lizards than expected captured and relocated	It is not possible to know exactly how many lizards will be captured, best efforts to estimate have been made based on the survey results. If 10% more than the anticipated numbers are captured, the following measures will be implemented.	Low-moderate	Salvage will continue until a decreasing trend in lizard numbers is established, for a minimum of three additional days, up to a maximum of five additional days. Additional relocation habitat may be necessary if more than 4,500 lizards are captured. Once 3,500 lizards have been captured contact DOC to discuss the requirement fo alternative release sites.	Very low
Residual lizard populations remaining following habitat clearance	It is unlikely every lizard will be captured from the works areas. The Wildlife Permit application includes the application for 'incidental killing' of lizards that elude salvage.	Moderate	Follow incidental discovery protocol.	Low

3.10 Incidental discovery protocol

The following protocols are to be followed if lizards are encountered on site during works, after lizard salvage has been completed. The protocol will be distributed to the construction team, including plant operators.

Lizards could be present in and on vegetation that has either not been cleared, or has established following initial clearance. Vegetation could include long grass, scrub and weedy vegetation. They may also bask in sunny exposed spots, such as in/on wood or rock piles, and may be found underneath debris. They may be uncovered when disturbed.

Following discovery of a lizard after salvage has occurred, the following steps will be taken:

- Immediately (as soon as discovery of a lizard is made) stop any activities within five metres of the discovery. If the species encountered is a species with a Threat Classification status of 'Threatened' then all works must cease immediately within 100 m, until an assessment is made of the risk for that species by the works, and any specific management identified, including avoidance.
- If possible, catch the lizard and place in a container with grass/leaf litter. Useful containers include clean lunch boxes or clean materials boxes. Ensure to create breathing holes in the container if the container is airtight. Store the lizard in the container in a safe, cool, shady location out of sun until a decision is made.
- Immediately inform the Project Herpetologist and site manager.
- Note the date, time, name of person who observed the lizard and the person who caught the lizard (if caught). Photograph the lizard/s and the habitat where it was found and record GPS location (e.g. a pin on Google Maps). A cell phone photo will be sufficient providing it is in focus. If the lizard was not captured, note any details possible (e.g. colour, body markings, size, body shape in order to describe to the Project Herpetologist or DOC.
- If the lizard is injured immediately (within one hour) contact the Project Herpetologist and a local veterinarian and arrange for the lizard to be transported to the veterinarian. Treatment by the veterinarian will likely require payment. Photograph the injury.
- If a dead lizard is found note the location it was found, the time it was found, and the approximate time of death if this can be determined (e.g. time materials where a lizard was found were moved). Notify the Project Herpetologist and DOC. If DOC require arrange for the carcass to be sent to Massey University Wildlife Postmortem Service, Massey University, in Palmerston North. If the carcass can be delivered within 72 hours, chill it, or if delivery will take longer, freeze it.

3.11 Checklist

Table 4 contains a checklist summarising the responsibilities for lizard management within the site.

Table 4. Lizard Management Checklist

Task	Required of:	Completed
Project start-up		
Appointment of project herpetologist	FHLD / Consent holder	
Finalisation of lizard management techniques and LMP	Project herpetologist	
Submission of final LMP to DoC / Council	Project herpetologist / FHLD	
Approval of LMP	DoC / Relevant authority	
Pre-works management prior to vegetation clearance		
Contractor induction regarding lizard management requirements	Project herpetologist / Site manager	
Installation of release-site pest control	FHLD or suitably qualified contractor	
Release-site enhancement planting and eco pile installation	FHLD / Landscape contractor	
Installation of lizard exclusion fencing around release area	Contractor under supervision of project herpetologist	
Deployment of ACOs, pitfall traps and / or funnel traps	Project herpetologist	
Pre-works lizard trapping and active searches	Project herpetologist	
Works phase lizard management		
Confirmation of salvage areas and habitat suitability	Project herpetologist / Site manager	
Machine assisted lizard capture	Project herpetologist, clearance contractor	
Post works		
Works completion report to client, Council and DoC	Project herpetologist	
Post completion monitoring (where required)	Project herpetologist	
Post-release monitoring (if triggered)	Project herpetologist	

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Appendix A
Assessment against the key principles for lizard salvage and transfer in New Zealand

Table 5. Assessment of the proposed works against the key principles for lizard salvage and transfer in New Zealand.

Principle		Discussion
1	Lizard species' values and site significance must be assessed at both the development and receiving sites	Surveys have been undertaken of the salvage site and relocation site confirming the presence of McCann's skink in the salvage and release sites (Figure 3), and the likely presence of tussock skink around the lake edge. The values of the release site were confirmed through surveys and hand searching. The release site currently has low-moderate values, in line with the majority of the lizard habitat in the rest of the site. Values will be increased through planting, enhancements and pest control, increasing the significance of the habitat as well. The significance of the site as a whole (salvage and relocation areas) was considered moderate to moderate due to the presence of Not Threatened McCann's skink. At Risk tussock skink were only present around the lake edge. The value of the site was considered to be lower due to the lack of native vegetation, and pressure from agriculture. McCann's skink is very common in the wider area, and eastern South Island.
2	Actual and potential development-related effects and their significance must be assessed	Section 2.7 of this report and section 4.2.2 of the EcIA discuss actual and potential effects. Direct effects include injury and mortality during physical works. Indirect effects include loss of habitat, habitat fragmentation, disturbance during works as a result of noise and machinery/vehicle movement and other construction activities, and changes in habitat due to application of treated wastewater. The significance of the wider site is not expected to change At Risk species are most likely to be present around the lake margins. The value and significance of areas to contain houses and commercial areas is likely to be reduced.
3	Alternatives to moving lizards must be considered	There are no areas of high value habitat in the site. The ongoing quarrying activities continue to impact habitat values. Development of the site means lizards must be moved out of harms way. Compensation in the form of enhancement elsewhere was not considered to address actual effects on site.
4	Threatened lizard species require more careful consideration than less-threatened species	The species expected to be encountered most is Not Threatened McCann's skink. Tussock skink habitat is minimal and mostly located outside of the site. It has been avoided as far as possible when it comes to development of the coves through minimising the number of coves and locating these in areas where there is already natural inlet topography. Where avoidance is not possible works have been minimised. Only very small numbers of tussock skink are expected to be encountered in very discrete areas (cove excavation).
5	Lizard salvage, transfer and release must use the best available methodology	Best practice methodologies have been proposed as per section 3.4 of this document. The LMP is considered to be a 'live' document, and can be updated if evidence requires alternative methodologies be considered. The release site will be subject to habitat enhancement, revegetation, pest control and ongoing protection in line with best practice.

6	Receiving sites and their carrying capacity must be suitable in the long term	The release site will not be subject to development. It will be protected via consent notices or covenants. It has been sized conservatively to accommodate expected numbers of lizards with significant redundancy. It is four times larger than the minimum size needed, and will be subject to habitat enhancements and pest control, increasing the carrying capacity significantly over and above what it would currently support.
7	Monitoring is required to evaluate the salvage operation	Post release monitoring is proposed as per section 3.7 of this LMP. The monitoring of translocated lizards to measure survivorship and population establishment is difficult without physically marking the lizards. Post release monitoring will therefore be focused on determining if population/s of lizards are persisting in the release site/s following salvage and release.
8	Reporting is required to communicate outcomes of salvage operations and encourage process improvements	Reporting regarding post release monitoring, and completion reporting, are proposed as per section 3.7 and 3.8 of this LMP.
9	Contingency actions are required when lizard salvage and transfer activities fail	The enhancement, revegetation and pest control of a larger area of habitat within the site than is necessary will support resident lizards in these areas and are expected to result in growth of the resident population even in the absence of lizards being released to these areas. Significant revegetation and landscape enhancements are occurring as part of the wider project, including around the lake margin. These activities will significantly increase habitat values for lizards beyond the site boundaries and will create new habitat opportunities in the site for lizards to move into of their own accord.

Appendix M: Draft Fish Management Plan

VIRIDIS
Environmental Consultants

Parkburn, Luggate-Cromwell Road

Draft Fish Management Plan

Prepared for: **Fulton Hogan Land Development Limited**

May 2026



DOCUMENT CONTROL AND REVISION HISTORY

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Cover photo: Upland bully (*Gobiomorphus breviceps*).

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1 INTRODUCTION

1.1 Purpose of this Fish Management Plan

This Fish Management Plan (FMP) has been prepared to manage the actual and potential adverse effects of the proposed works on freshwater fish and fish habitat associated with the Parkburn residential subdivision development at 922 Luggate-Cromwell Road, Cromwell.

The FMP outlines procedures for:

- the installation and maintenance of fish exclusion devices;
- fish salvage and relocation;
- fish handling and transportation;
- relocation site selection;
- biosecurity measures;
- monitoring and reporting requirements; and
- adaptive management during works.

The purpose of these measures is to minimise adverse effects on freshwater fish during instream works within Park Burn and excavation works associated with the proposed Lake Dunstan coves.

This draft FMP accompanies the Fast-track Approvals Act 2024 (FTAA) application and will be finalised following confirmation of the detailed construction methodology and any relevant consent conditions.

1.2 Project Background

Fulton Hogan Land Development (FHLD) Limited has applied for resource consent through FTAA to develop a residential subdivision on the property at 922 Luggate-Cromwell Road (State Highway 6), Cromwell.

The proposed development includes:

- replacement of the existing triple-arch culvert with a bridge crossing;
- excavation of two coves along the margin of Lake Dunstan; and
- associated earthworks and infrastructure works.

As these works will occur within or adjacent to freshwater habitats, there is potential for adverse effects on freshwater fish and aquatic habitat..

This FMP should be read in conjunction with the Parkburn Ecological Impact Assessment Report ('EcIA')[1], which assesses the ecological values of the site and the potential effects of the proposed works.

[1] Viridis. 2026. Parkburn, Luggate-Cromwell Road, Ecological Impact Assessment. Prepared for Fulton Hogan Land Development Limited.

1.3 Site description

The site contains two freshwater environments relevant to this FMP:

- Park Burn, an intermittent stream flowing through the site; and
- the margins of Lake Dunstan adjacent to the proposed cove excavation areas.

The location of the site is shown in Figure 1.

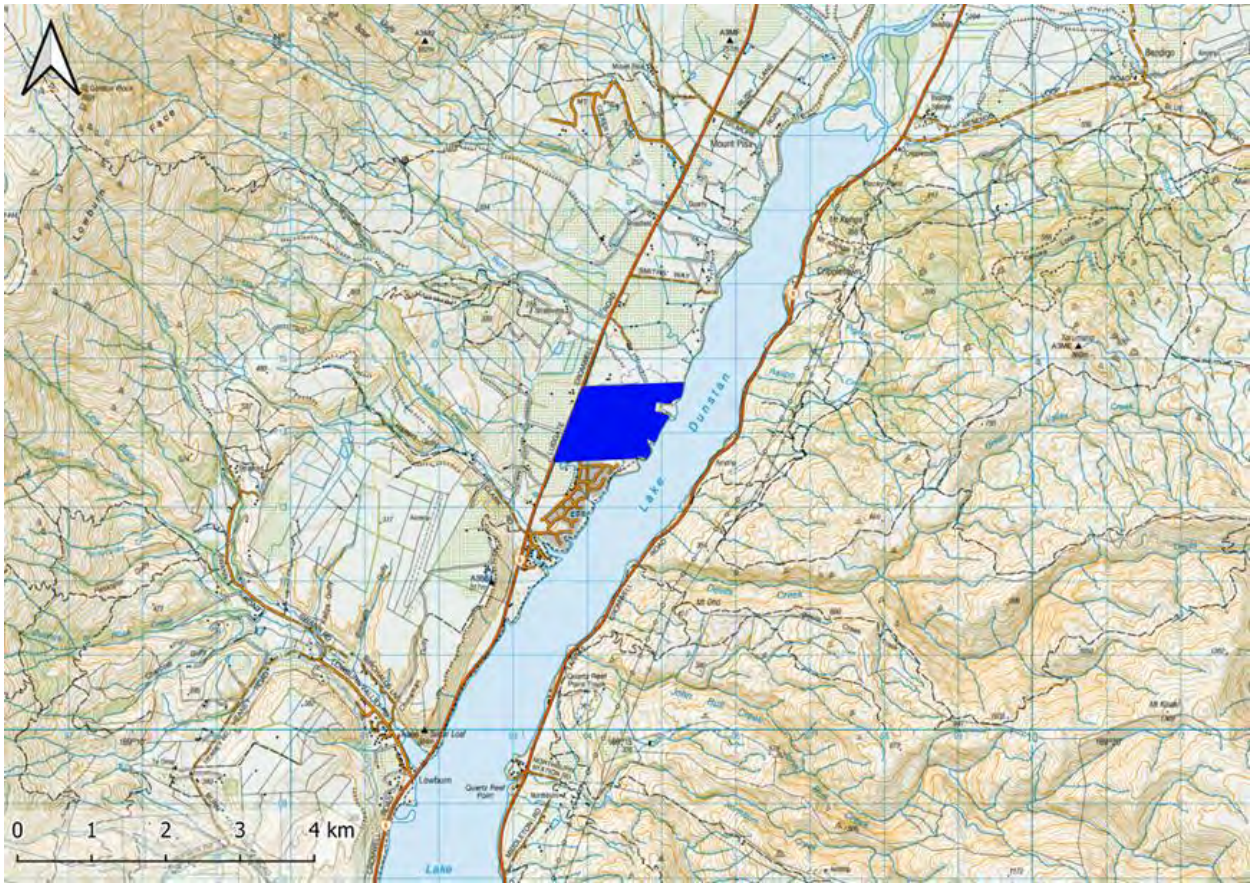


Figure 1. Site location as indicated by blue polygon (map source: LINZ NZ Topo 50).

1.3.1 Park Burn

One intermittent stream, Park Burn, flows through the site. It originates northwest of the site, on the Lowburn Face of the Pisa Range. The upper reaches flow through extensive agricultural land, while the lower reaches (on the river flats) flow through horticultural land. It flows into Lake Dunstan immediately to the east of the site.

Within the site, the Park Burn is contained within a small gully, approximately 30 m wide, that has not been subject to quarrying. Substrates were dominated by gravels with smaller areas of fine sediment, and given sufficient flow, small braids can form (Figure 4). It periodically runs dry, therefore it has been classified as intermittent.

Park Burn is considered to have moderate ecological values. Despite its modified nature, there is the potential for At Risk fish species to be periodically present.

a)



b)



Figure 2. Park Burn within the site.

1.3.2 Lake Dunstan

Lake Dunstan is an approximately 26 km^2 hydroelectric lake, formed in the 1990s following the construction of the Clyde Dam. Prior to the lake being filled, the moderately braided Clutha River flowed in its place. The lake is long, narrow and relatively shallow, occupying a river valley.

The lake is considered to have high ecological value due to it providing habitat for a number of Threatened and At Risk fish and bird species.

a)



b)



Figure 3. Lake Dunstan adjacent to the site.

1.4 Fish Values and Species Potentially Present

A survey of Park Burn within the site yielded a single common bully (*Gobiomorphus cotidianus*, Not Threatened). Records for the Park Burn in the New Zealand Freshwater Fish Database have only recorded brown trout (*Salmo trutta*; Introduced and Naturalised) to date. Records for Lake Dunstan, and for its tributaries record the presence of various species.

The presence of hydroelectric dams downstream means any eels present in Park Burn or Lake Dunstan have been present since prior to the installation of the dams. Numbers are expected to be low, if any in Park Burn, but they are expected to be present in the lake. Clutha flathead galaxias have been recorded in a tributary of the Low Burn, southwest of the site. It is considered unlikely they are present in the site itself due to their non-migratory status and they do not reside in lakes. Koaro populations have also

likely been impacted by the hydro dams as they are a migratory species requiring a period in the sea for reproduction. However, there are landlocked koaro populations, including in the Central Otago lakes.

Species expected to be present within Park Burn or Lake Dunstan include:

- Longfin eel (*Anguilla dieffenbachii*, At Risk - Declining)
- Shortfin eel (*Anguilla australis*, Not Threatened)
- Common bully
- Upland bully (*Gobiomorphus breviceps*; At Risk – Naturally Uncommon)
- Brown trout (*Salmo trutta*, Introduced and Naturalised)
- Koaro (*Galaxias brevipinnis*; At Risk – Declining)
- Rainbow trout (*Oncorhynchus mykiss*; Introduced and Naturalised)
- Perch (*Perca fluviatilis*; Introduced and Naturalised)

1.5 Objectives of Fish Salvage and Relocation

The objectives of fish salvage and relocation are to:

- minimise injury and mortality to freshwater fish during works;
- prevent fish entering active work areas;
- safely capture and relocate fish from affected habitats;
- relocate fish to suitable habitat within the same catchment;
- minimise stress during capture, handling, transport, and release;
- ensure works are undertaken in accordance with relevant permits and industry best practice; and
- maintain appropriate biosecurity controls.

1.6 Roles and Responsibilities

The roles and responsibilities associated with implementation of this FMP are outlined in Table 1.

Table 1. Roles and responsibilities

Role	Responsibility
Supervising freshwater ecologist	Oversee implementation of the FMP; undertake fish salvage and relocation; determine salvage effort requirements; supervise fish handling and release; implement adaptive management measures where necessary; record fish capture data; and prepare post-salvage reporting.
Contractor	Install and maintain fish exclusion devices as directed by the freshwater ecologist; provide safe access to work areas; comply with directions provided by the freshwater ecologist; and ensure works are undertaken in accordance with this FMP.
Project manager / consent holder	Ensure relevant permits and approvals are in place prior to works commencing; coordinate timing of salvage works; ensure resource consent conditions are complied with; and provide required reporting to Otago Regional Council where applicable.

2 METHODOLOGY

The methodology outlined below describes the procedures that will be implemented to minimise adverse effects on freshwater fish during works within Park Burn and Lake Dunstan.

2.1 Timing

Fish salvage and relocation will be undertaken immediately prior (within 2-3 days) to the commencement of any instream works or cove excavation. Ongoing maintenance of any temporary fish barriers by the contractors will be undertaken until stream and cove excavation works are complete within the area. Fish salvage should preferentially occur during the drier summer months when weather is generally more settled. No salvage should occur if moderate or higher rainfall is forecast for the salvage period.

2.2 Exclusion devices

Prior to commencing works on Park Burn barrier(s) will be installed to prevent fish moving up and downstream through the area of works. Exclusion devices are still required on Park Burn if it is dry as a period of rain may set the stream flowing again.

Isolation devices are considered impractical for the cove excavation due to the size of the area and depth of the lake.

Exclusion devices will be constructed from steel warratahs and shade cloth, or similar. Shade cloth, or a similar material, allows water to continue to flow downstream while preventing fish passage. The exclusion screen will extend at least one metre past the wetted width of the aquatic habitat and will be embedded into the dry ground or the banks (Figure 5).

Waratahs will be securely hammered into the ground and evenly spaced across the stream to support the shade cloth. Where extra support is necessary, i.e. if the flow is very swift, wire will be threaded horizontally through the waratahs. Shade cloth will be fastened to the waratahs and wire supports (where applicable) using zip ties or similar mechanism. The shade cloth will extend approximately 0.5 m above the water level. Along the stream bed the shade cloth will either be embedded and pinned or securely weighted down, or an apron of the shade cloth will be formed and pinned. This creates a pocket, preventing fish from passing under the barrier.

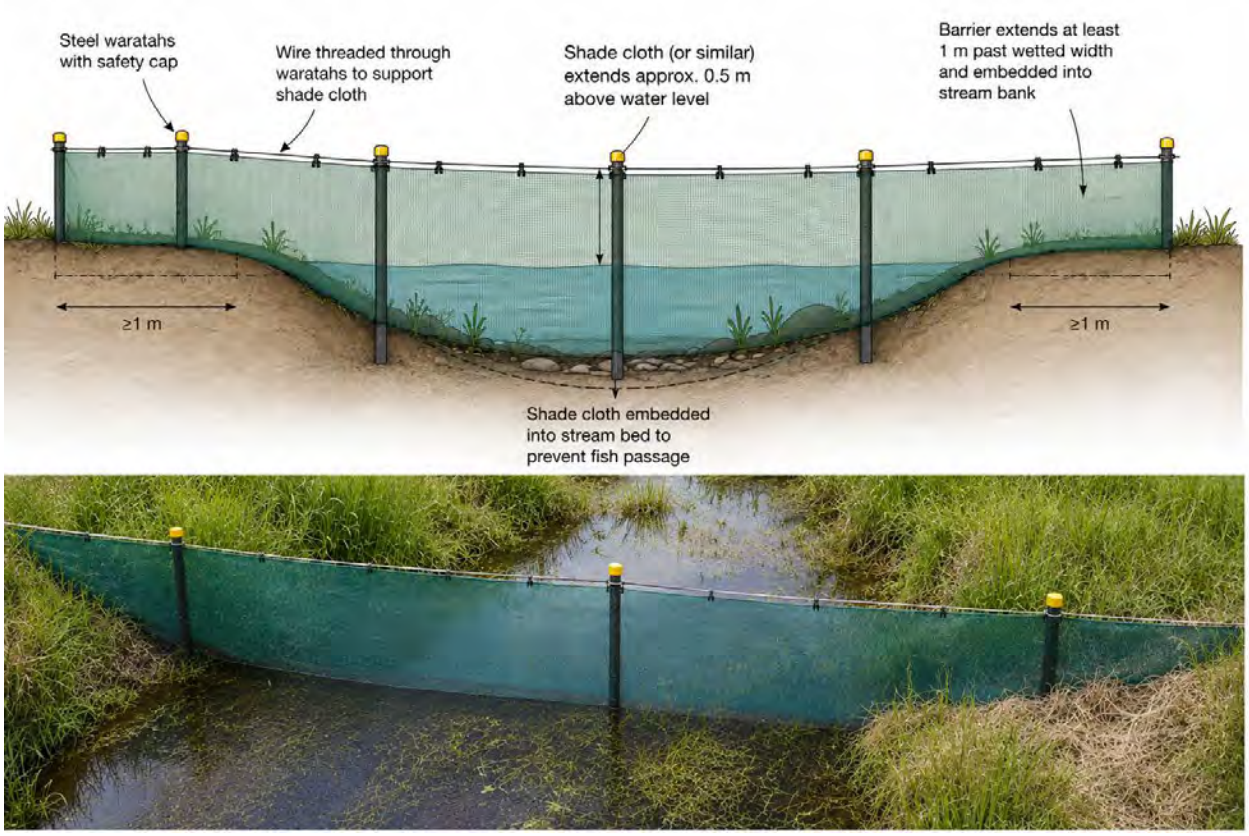


Figure 5. Example of a fish barrier installed in a stream to prevent passage into or out of an area.

2.3 Fish capture

2.3.1 Park Burn

If the Park Burn is dry at the time of works, no fish salvage is necessary.

A combination of electric fishing and netting/trapping is proposed within the Park Burn if water is present. If water is not present, but saturated mud/sediment is present in the Park Burn, this should be searched for eels.

The *New Zealand Freshwater Fish Sampling Protocols* (Joy *et al*. 2013) will be followed unless specified within this plan.

Electric fishing will be undertaken in the works reach prior to setting any nets. Several passes may be undertaken depending on fish capture rate. Following electric fishing and providing water levels allow, baited Gee's minnow traps and fyke nets will be placed at intervals over the stream works areas and left in place overnight. Fine meshed fykes with a separator grill will be used if depth allows. All nets and traps will be set with an airspace to provide trapped fish access to atmospheric oxygen and will be set in general accordance with Joy et al. (2013). Floats will be placed in the fyke nets if required to ensure an airspace is available. The traps will be checked the following morning, prior to 9 am, with any captured fish recovered.

Trapping densities will be set, at minimum, at least one fyke net and two Gee's minnow traps over 25 m, in accordance with Joy et al., (2013). However, if sufficient length and depth of water is present, the densities of traps and nets may be increased if deemed appropriate by the supervising freshwater ecologist. Where water depth prevents fykes being set, the densities of Gee-minnow traps will be

increased and hand-netting of any aquatic habitat (e.g. pools, overhanging vegetation, woody debris) will be undertaken. Hand netting will occur moving up the impact reach to sweep for any fish present within the channel which may not be able to move into the traps due to the shallow water depth. Hand netting will cease when less than two indigenous fish are captured. If water depths are not suitable for Gee's minnow traps, hand netting will still occur.

If more than 20 native fish are caught during a single trapping effort within the target area, trapping will continue until numbers are depleted to the satisfaction of the supervising freshwater ecologist (using an 80% removal rate as a target, based on the Hayne's (1949) regression method). A single trapping effort is considered to be one night of trapping. Target removal rates will be adjusted to 95% if any Threatened or At Risk species are captured. Electric fishing will be undertaken again following clearance of the nets.

While a streamworks methodology has not yet been confirmed, it is expected works within Park Burn will be required to occur 'in the dry'. At this point, bunding or sheet piling or similar will be installed to isolate the works area. Complete dewatering of the works area will commence provided capture rates have declined to the appropriate thresholds. All pumps used for dewatering will be appropriately screened to prevent fish being entrained in the pump. Screens will have gaps no larger than 3 mm. Native fish, such as eels (*Anguilla* spp.), will burrow into silt substrates when they are disturbed or as water levels decrease. As a result of this, during the dewatering stage, the supervising freshwater ecologist will be present to search through drained habitat, rocks/debris, remaining pools or thick sediment for any remaining fish. Once dewatering is completed an excavator will be used to carefully scrape out any thick layers of sediment, if necessary. A toothed bucket will not be used on the excavator. In our experience it is more effective to use a non-toothed bucket. Providing a minimum depth of approximately 200 mm of sediment is scraped, any eels buried within the mud will be scooped up unharmed. Toothed buckets are inefficient for 'muck outs' as the teeth mean a shallower depth is scraped.

2.3.2 Cove excavation

While a works method for excavation of the coves has not yet been confirmed, it is expected some level of excavation within the lake itself will be required. It is not feasible to completely isolate the works area due to the size of the excavation area, depth of Lake Dunstan, and the open connectivity of the lake environment. Fish are also able to freely move into and out of the excavation area, meaning pre-construction salvage would likely result in only temporary and incomplete removal of fish from the area. The works area represents a very small proportion of the lake habitat and effects of works are considered to be very low.

As a result, salvage associated with excavation of sediments during works is considered the best practicable method to minimise adverse effects on fish within the lake environment. This approach focuses on recovering fish that may become entrained within excavated sediment, particularly benthic species and burrowing species such as eels.

The supervising freshwater ecologist will be on site for all excavation works that are in direct contact with the waters of Lake Dunstan. Excavated material will be deposited on the banks of the lake to allow any eels present to naturally move back into the lake. In addition, the ecologist will manually search through all excavated sediment for any fish entrained within the sediment.

A toothed bucket will not be used on the excavator. In our experience it is more effective to use a non-toothed bucket. Providing a minimum depth of approximately 200 mm of sediment is scraped, any eels buried within the mud will be scooped up unharmed. Toothed buckets are inefficient for 'muck outs' as the teeth mean a shallower depth is scraped.

2.4 Handling of fish

Fish handling will be in accordance with Section 3.9 of the *New Zealand Freshwater Fish Sampling Protocols* (Joy *et al.* 2013) and the Viridis MPI Special Permit (875) and Native Fish Transfer Authorisation (NFT420).

All fish captured in traps/nets or via electric fishing, will be immediately transferred to water-filled, lidded containers of an appropriate volume for the number of fish captured. Multiple containers will be used if necessary. Containers will be stored in the shade. Fish will be stored in the containers for no more than one hour. If storage for longer is required, water will be changed at least once per hour and/or a battery powered air pump will be placed in each container to ensure oxygen levels are sufficient. A water conditioner, such as API Stress Coat may be added to the water to reduce fish stress. Water conditioner will be added as per manufacturer instructions.

If any individual captured fish shows signs of stress (loss of righting response, exuding excessive mucus, gulping air, and/or mouth gaping) the water will be changed to provide more oxygen, or the fish will be moved to the relocation site immediately.

Fish will be visually examined for general health (visual skin lesions or heavy fungal burdens) and if considered unhealthy by the supervising freshwater ecologist, they will be humanely euthanised in accordance with condition 14 of the MPI Native Fish Transfer Authorisation (420).

Large eels (> 500 mm) will be contained individually to avoid injury to other smaller captured fish. Kōura (*Paranephrops sp.*), if present, will also be separated into their own containers.

Captured fish will be securely transported to the relocation site and gently transferred into the stream within two hours of being captured. If large numbers of fish are captured, they will be distributed across multiple release points in the general area to avoid short term overstocking and predation risks.

2.5 Relocation site

2.5.1 Park Burn

Fish captured within the Park Burn will be released back to the Park Burn upstream of the works area (Figure 6). Access is readily available from Luggate-Cromwell Road. Keeping fish within the same system they are salvaged from removes the risk of increased population densities, unsuitable habitats and biosecurity risks. There is sufficient upstream habitat to support additional fish species for the short period works will occur.

2.5.2 Lake Dunstan

Any fish captured from the Lake Dunstan will be returned to the lake (Figure 6). Whether they are returned to the lake to the north or south of the site will depend on any sediment released into the lake environment. Access is readily available to both the north and south of the works sites.

2.6 Biosecurity

All equipment will be thoroughly cleaned and dried prior to use. Equipment includes, but not limited to: electric fishing machine, waders, fyke nets, Gee's minnow traps, stop and dip nets and transfer buckets.

Any pest fish caught will be humanely euthanised and all euthanised pest fish will be disposed of in a biosecure manner to land, in accordance with condition 20 of MPI Special Permit 875 and 16(d) of Native Fish Transfer Authorisation 420.

2.7 Adaptive Management

Due to the high level of intrinsic variability in any fish recovery and relocation, this plan may be slightly modified by the supervising freshwater ecologist to ensure fish are recovered in a safe and professional manner, as well as in accordance with the *New Zealand Freshwater Fish Sampling Protocols* (Joy et al. 2013).

2.8 Contingency Measures

Unexpected conditions may arise during fish salvage, relocation, dewatering, or excavation works. The following contingency measures will be implemented where necessary to minimise adverse effects on freshwater fish and aquatic habitat.

2.8.1 Rainfall events

Fish salvage and relocation will not be undertaken during periods of moderate or heavy rainfall, or where such conditions are forecast during the proposed salvage period. Elevated flows and reduced water clarity can reduce salvage effectiveness and increase risks to both fish and personnel.

If significant rainfall occurs during salvage or instream works, activities will cease until flows and water quality have stabilised to a level considered suitable by the supervising freshwater ecologist. Following any significant rainfall event, fish exclusion devices and isolated work areas will be inspected to confirm they remain functional and secure.

2.8.2 Fish mortality

If unexpected fish mortality occurs during salvage, handling, dewatering, or excavation works, the supervising freshwater ecologist will investigate the likely cause and determine whether modifications to salvage methods, handling procedures, work practices, or fish holding arrangements are required.

Any significant fish mortality event, including mortality of Threatened or At Risk species, will be recorded and reported to the relevant regulatory authority where required by resource consent conditions or permit requirements.

2.8.3 Discovery of Threatened or At Risk species

If Threatened or At Risk fish species are captured in greater numbers than anticipated, salvage methodologies and effort may be modified by the supervising freshwater ecologist to increase capture efficiency and reduce adverse effects on the affected species.

Where necessary, additional salvage effort, increased trap densities, or revised handling and relocation procedures may be implemented. Works within the affected area may be temporarily delayed if considered necessary by the supervising freshwater ecologist to ensure appropriate management of the species.

2.8.4 Equipment failure

In the event of equipment failure during salvage or dewatering activities, works will cease until the equipment is repaired or replaced, where failure may compromise fish salvage effectiveness, fish safety, or environmental protection measures.

Backup equipment, including spare nets, buckets, aeration devices, and dewatering pumps (where practicable), will be available during salvage operations to minimise delays and risks to fish.

3 REPORTING

Following completion of fish salvage and relocation works, a short report will be prepared detailing the fish captured (species and number of fish) during the recovery, as well as details on the relocation site. Otago Regional Council shall be provided with a copy of the report within five days of completion of all fish relocation works. Data can be made available following the completion of stages if works are to be staged.

Fish records will also be sent to NIWA to be included in the New Zealand Freshwater Fish Database.

Reporting will be in accordance with any resource consent conditions.

4 PERMITS

Viridis holds an MPI Special Permit (875) and Native Fish Transfer Authorisation (420) that allows Viridis Limited, and their agents, representatives, and employees to take and relocate aquatic life to a suitable habitat where this is necessary or required to mitigate adverse effects of habitat modification on the aquatic life.

As the capture and relocation sites are not within a conservation area and since any fish captured will be relocated within the same catchment, no other permits are considered necessary.

Appendix N: Construction Traffic Management Plan

(to be provided in Final EMP)